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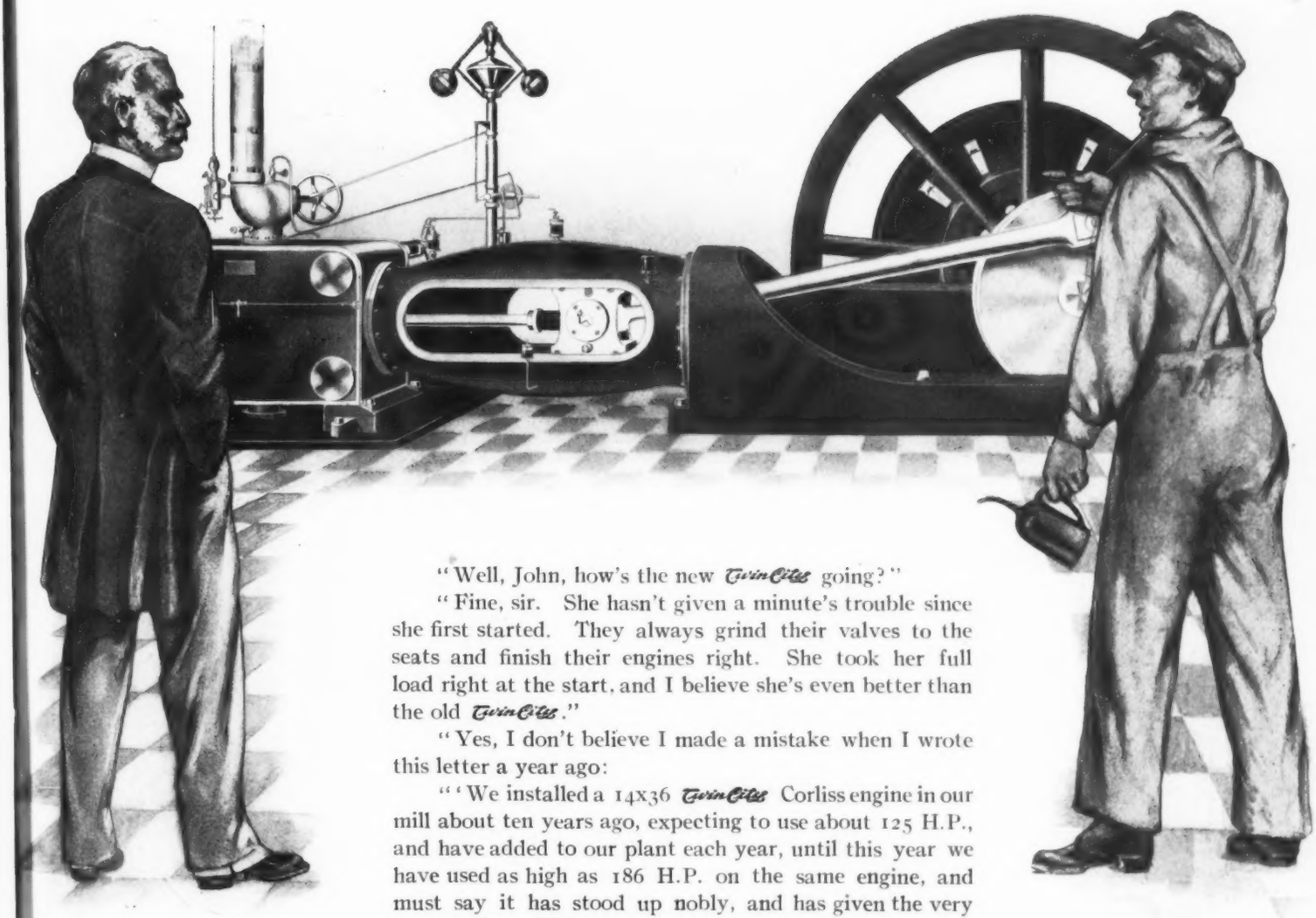
POWER AND THE ENGINEER

ISSUED WEEKLY BY THE HILL PUBLISHING COMPANY, 505 PEARL STREET, NEW YORK.

Vol. 29 Index to Advertisers and Classified Index Following Readng Matter No. 5.

Twin City CORLISS ENGINE



"Well, John, how's the new Twin City going?"

"Fine, sir. She hasn't given a minute's trouble since she first started. They always grind their valves to the seats and finish their engines right. She took her full load right at the start, and I believe she's even better than the old Twin City."

"Yes, I don't believe I made a mistake when I wrote this letter a year ago:

"'We installed a 14x36 Twin City Corliss engine in our mill about ten years ago, expecting to use about 125 H.P., and have added to our plant each year, until this year we have used as high as 186 H.P. on the same engine, and must say it has stood up nobly, and has given the very best of satisfaction. We never are obliged to shut down our mill on account of failure in the engine room.

'The cost of operating this engine is about 2½ lbs. of coal per horse power. We consider it one of the most economical engines manufactured today, and has cost us nothing to keep in repair.

'We expect at no late date to double the capacity of our mill, and feel that the Twin City Corliss engine will be the only engine considered.'"

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Let us loan you
A Dean Boiler Tube Cleaner
for a thorough test in one boiler

If we can't prove to you by that test that the DEAN removes scale more thoroughly, with greater ease, in less time, and at less cost than any other device on the market you may fire it back at our expense and you won't owe us a red cent.

We know what the DEAN can do—so do 8000 steam users—but maybe you don't and that is just why we want you to try it.

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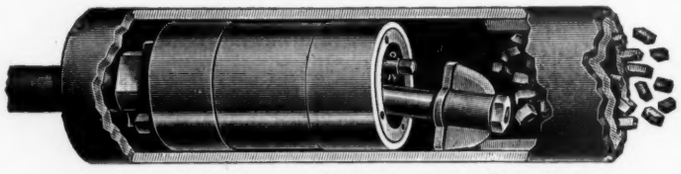
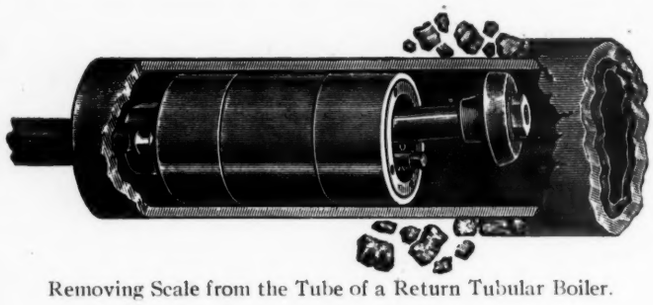


Removing Scale from the Tube of a Water Tube Boiler.



Removing Scale from the Tube of a Return Tubular Boiler.

Well, surely you're game enough to investigate, aren't you? That's all we ask you to do. And mind you, you don't have to keep the cleaner unless you are both happy and satisfied—no siree!

We send as many DEANS on trial to concerns who claim their boilers are "clean" as we do to those who know their boilers are dirty—and they "stick" because nine times out of ten the boilers are dirty—Inspectors' reports and Engineers' opinions notwithstanding.

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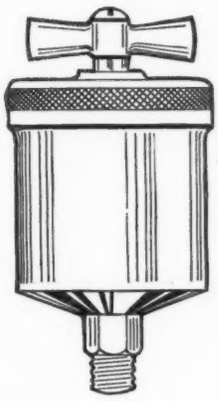

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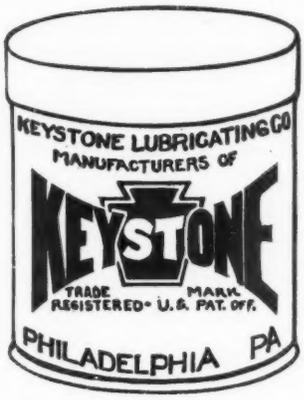

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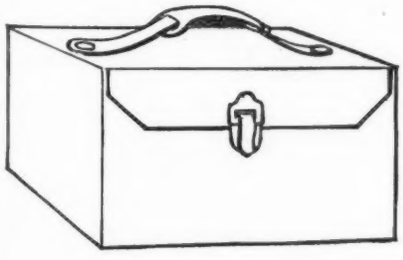

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Size of tap for cup .....
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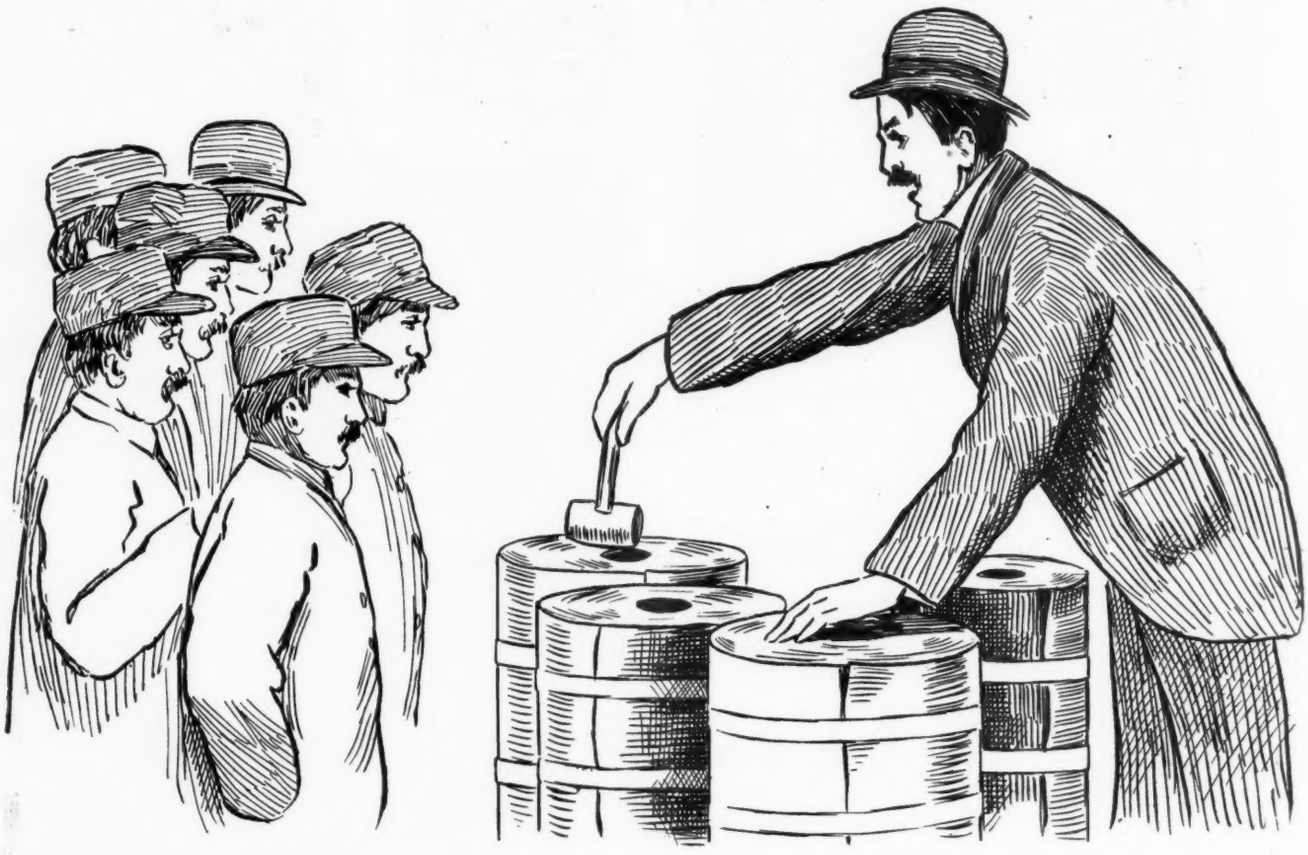

Auctioneer: "Now, gentlemen, I am going to dispose of the entire stock of the Old Fogy Packing Supply Co. What am I offered for this roll of Antiquate sheet packing? Something fine, I guess. Sure to give satisfaction. What am I offered a pound? One dollar? Seventy-five cents? Come boys, don't let this chance slip by. What will you start it at? Twenty-five cents? No bid? All right, pass it along.

Now, gentlemen, step up closer, please. I am going to offer you something special—something you want. This celebrated Before-The-Flood packing. There's quality in every inch, gentlemen, in every inch! Now, what am I offered a pound? Ten cents? What? Ha! Ha! Well, let her start at that. Now, boys, ten cents, ten cents. Who'll make it fifteen? Come boys, I can't make a sale on one bid. Who'll make it fifteen? No offer? Then we'll have to pass it up.

I guess, boys, you're out for something choice. Well, here it is, the choicest ever! A black sheet packing that's a Cracker-Jack. What's that? Is it Ebonite? Well, no, but I guess it's just as good." (Chorus of voices) "There is no packing that's just as good as EBONITE Black Sheet Packing. We know! We've tried Daniel's EBONITE for superheated steam, high steam pressures, hot and cold water, oil, ammonia, gas, and everywhere you can use a packing, and there isn't anything that can touch EBONITE."

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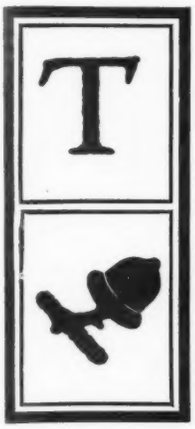
The House of Dearborn



THERE is always one great pioneer and leader in the development of every important industry. Twenty years ago, the fact that great savings could be made in fuel consumption and that boilers and boiler tubes could be made to last much longer, but for the detrimental action of boiler feed waters, interested some young chemists in Chicago in the possibility of surmounting this difficulty by making careful analytical study of different classes of waters, and finding scientific reagents for the elements that produced the trouble.

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With its large corps of representatives, all of whom are *mechanical experts*, working in all sections of the country, backed by the scientific laboratory work done at Chicago, the Dearborn Company is able to give personal attention to every case, making careful study of the water and plant conditions and furnishing treatment that exactly meets requirements.

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Coated Corrugated
GASKET
Ready for use.

Look For The Label

As there are gaskets on the market which imitate the Smooth-On, you cannot be sure you are getting what you pay for unless you look for the label. See that the Smooth-On label is there and you'll be sure you are getting the best gasket made; the one coated with our elastic iron cement; the one that makes permanently tight joints.

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High Class Results FROM Low Grade Fuels

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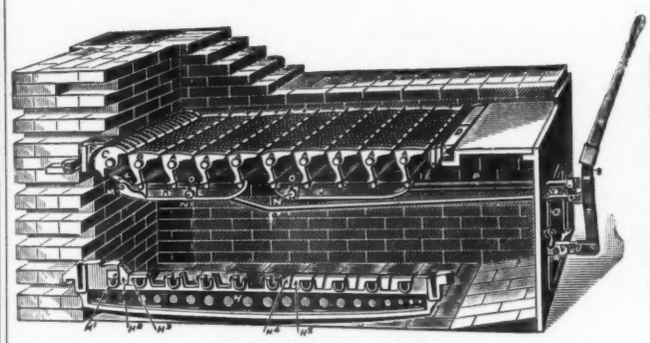
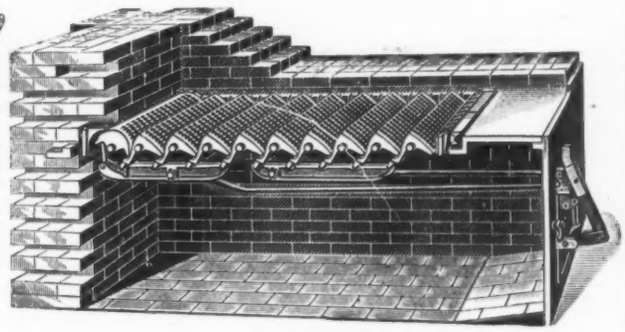
'Tis folly to use high grade expensive coal when the same results can be obtained with *cheap fuel*, provided it is burned according to the McCLAVE SYSTEM.

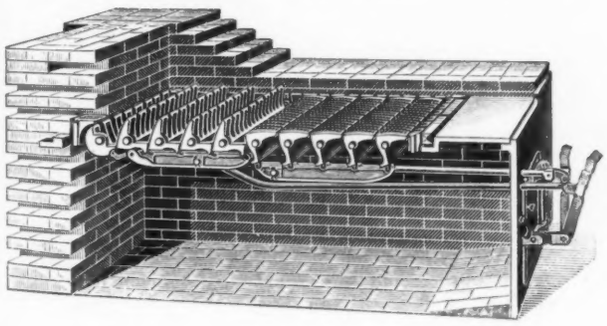
Such fuel as anthracite birdseye, rice, bituminous slack, screenings, duff, etc., are completely consumed without waste. Fire can be cleaned uniformly from front to rear with doors closed. The Argand Blower delivers a large volume of air with a small amount of steam and is superior to natural draft for burning the smaller coal fuels. Let us explain more fully. Catalog "G"?



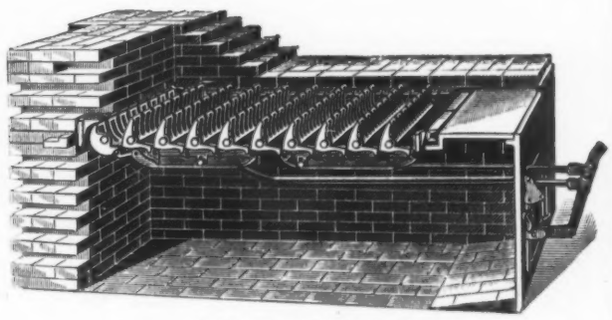
Normal Position of Grate.



Shaking Movement.



Divided Cut-Off.



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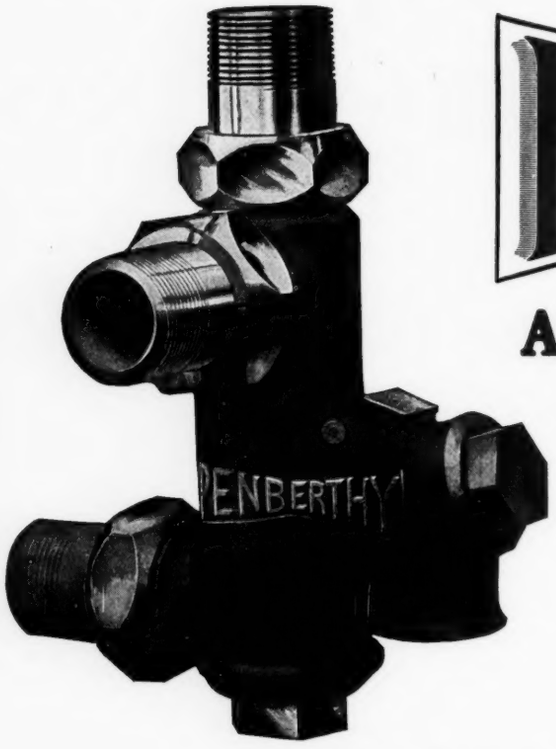

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AUTOMATIC INJECTOR

Always "Makes Good"

1st—It will work on higher pressure and handle hotter water.

2nd—It will lift further vertically on a greater range of pressure.

3rd—It delivers a maximum amount of water with a minimum amount of steam.

Try the PENBERTHY it never fails.

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Has no equal in lifting or elevating liquids. Used Exclusively by the leading creameries, tanneries, breweries, brickyards, distilleries and dye houses in the country.

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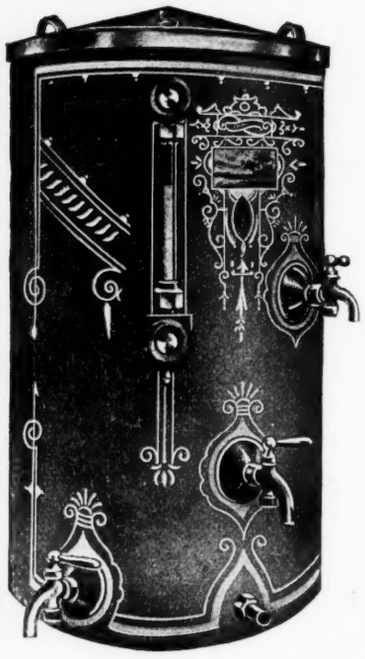

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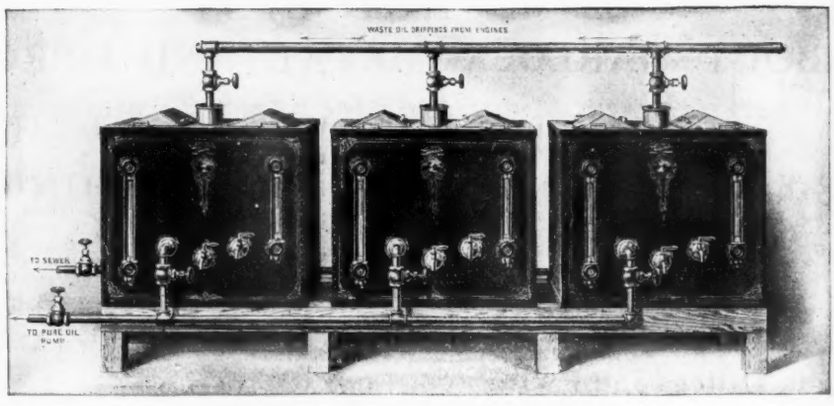
Largest Manufacturers of Oil Filters in the World.

A Recommendation Of "Burt" Unit Oil Filters Beyond Dispute

It is one thing to *write* a recommendation, but the best proof of excellence is when the customer *keeps buying* more.

After a series of most exacting tests, the Philadelphia Rapid Transit Co., which operates eight of the most modern power plants in the U. S, selected six "Units" over all of the leading makes of filters on the market—a short while after they added four and recently they installed ten—making a total of twenty-six "Units" in all. That's proof, isn't it?

You can't get around a recommendation of that caliber.



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Unit Filters can be operated with or without an oiling system and can be operated singly or with a number, so as the plant increases additional "Units" may be added.

In our new 92-page catalog just issued—the most handsome catalog ever put out by any oil filter concern—you'll find all the particulars. If you are connected with power plants or a manufacturing concern, you should certainly get a copy. It also contains a description of our Cross "American" and Warden Oil Filter, The Burt and Standard Exhaust Heads and the Burt Ventilators.

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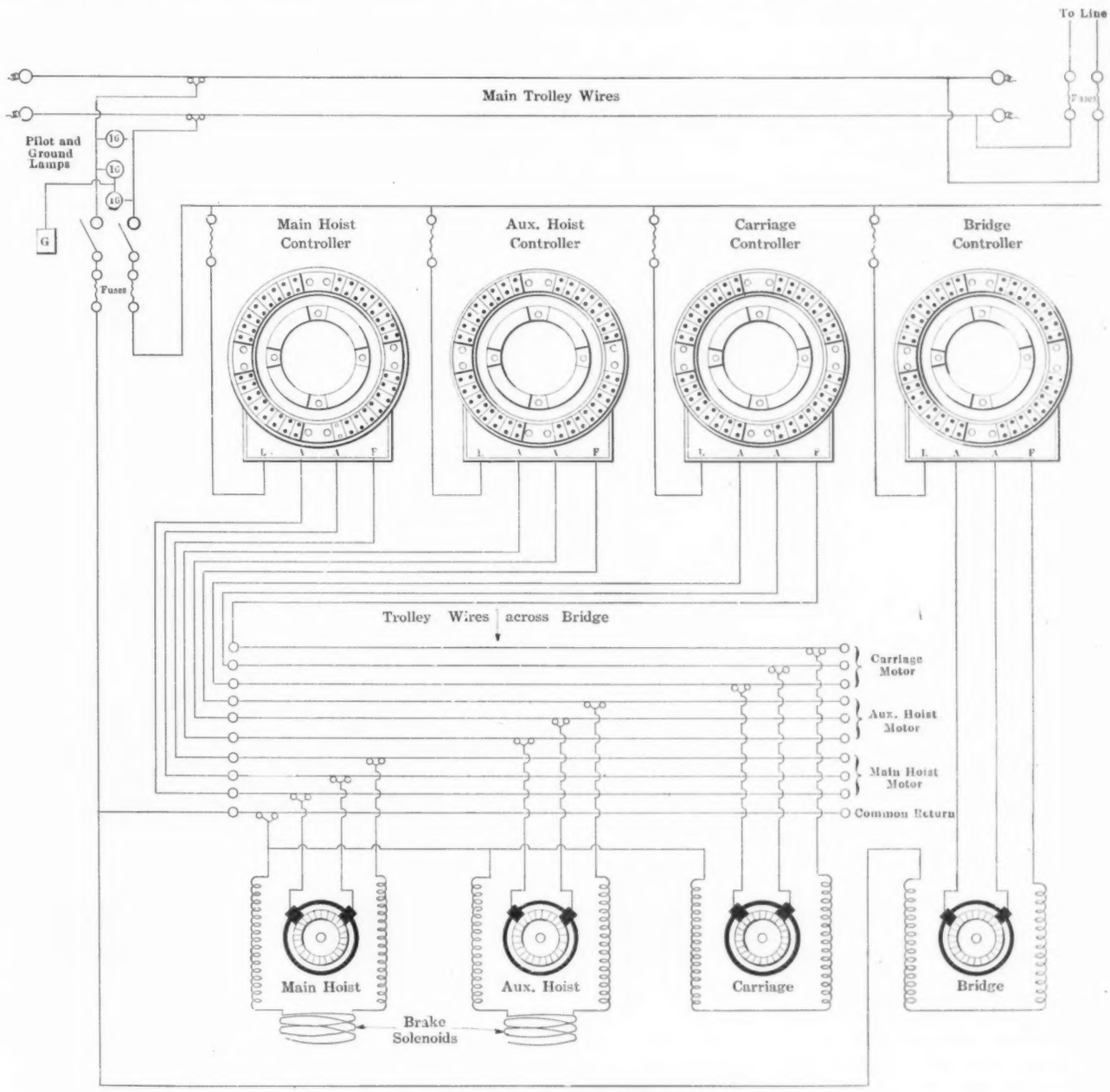
The Equipment of Electrical Cranes

Choice and Care of Motors; Hoists and Brakes; Local Electrical Equipment and Connections; Troubles Liable to Be Encountered

BY R. H. FENKHAUSEN

Electric cranes are now universally used where material must be frequently handled, and as they are usually operated by unskilled labor, many slight difficulties are encountered due to careless handling. Nearly all cranes are equipped with three motors, the bridge motor, which drives the crane up and down the track, the "trolley" motor, which drives the carriage laterally across the bridge, and the hoist motor, which does the actual lifting of the load and is usually the largest motor on the crane. In addition to these, some cranes carry an auxiliary hoist, mounted either on the main carriage or on a separate one. This hoist may be of the same capacity as the main hoist, but it is usually arranged for high-speed lifting of comparatively light loads.



PIG. I. DIRECT-CURRENT CRANE CONNECTIONS

The controllers for the various motors must be of the regulating and reversing

type and may be placed either in a cage suspended from one end of the crane, in which the operator is stationed, or operated by pendant rods or cords from the floor. The latter method is used only on small cranes.

The motors may be of either the direct-current series-wound type, or of the alternating-current polyphase induction type with speed control by variation of the primary voltage. Single-phase series-wound motors also are available; these are very similar in both appearance and operating characteristics to the series-wound direct-current motor.

Any one of the motors mentioned will give satisfaction if properly installed, and the choice of motor, therefore, may be determined by the current that is available.

Inspecting a New Crane

Even though a new crane is supposed to have been thoroughly tested by the builders, there are a few points it is well to check up. The diameters of the driving wheels on opposite sides of the crane should be carefully tested, as any difference in size, however slight, will put a severe strain on the driving gears and shaft, and overload the motor by reason of the tendency of one side of the bridge to travel faster than the other. All gearing and shafts should be turned through several revolutions by hand, in order to make sure that there are no high teeth and that nothing has been bent or sprung in shipment, before current is turned on the motors. The gage of the tracks should be tested, as any variation will cause the wheels, which are usually double-flanged, to bind on the flanges, causing overloading of the motor and probably resulting in a broken wheel and its attendant dangers.

A brake, preferably automatic, should always be provided for the bridge motor; any saving in current by the coasting of the crane is more than offset by the motor repairs entailed by the reversal of the motor when the operator wishes to stop quickly.

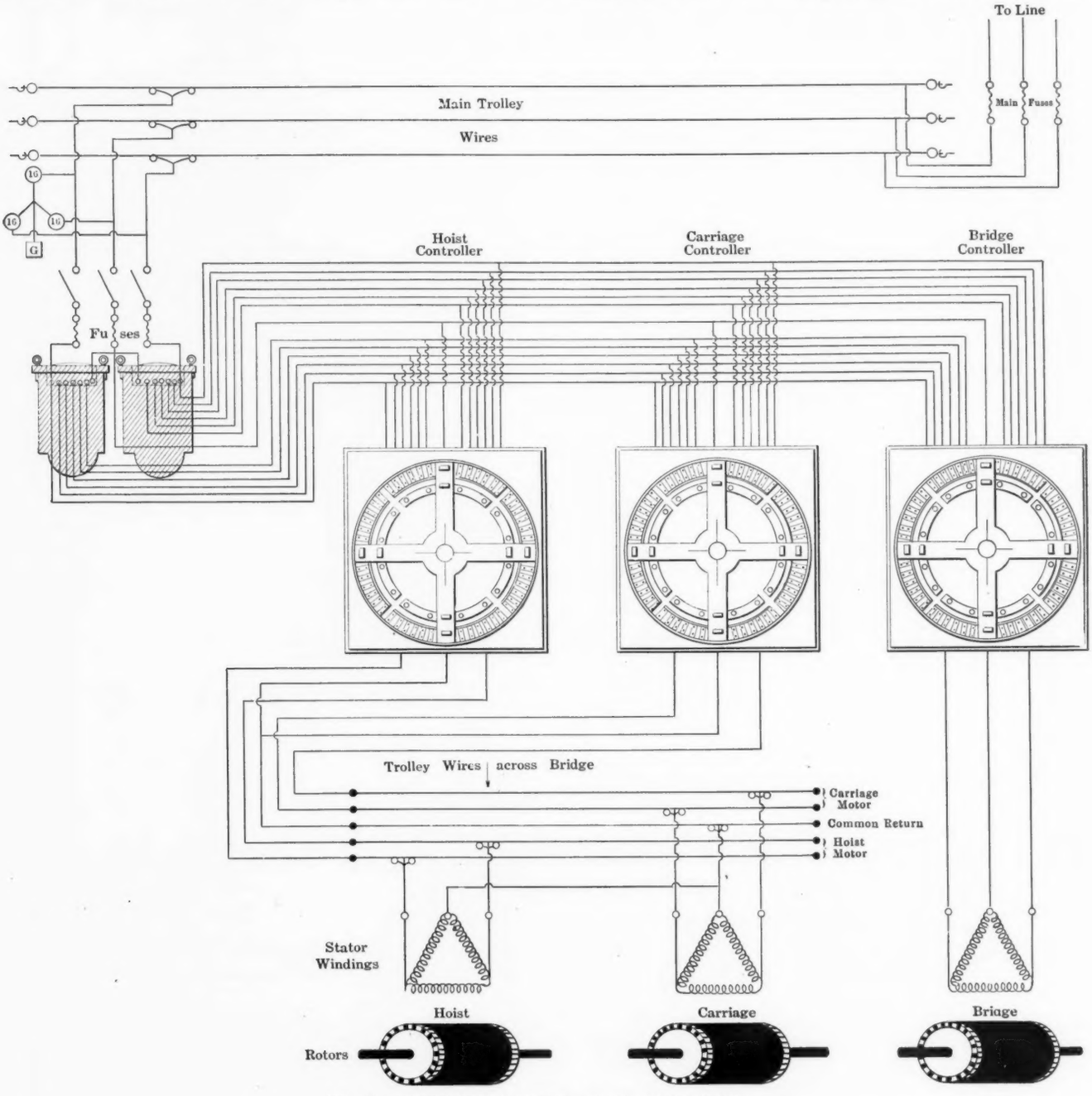


FIG. 2. ALTERNATING-CURRENT CRANE CONNECTIONS

Local Electrical Equipment

The main trolley wires should be protected by a fuse where they are connected to the feeder, so that a short-circuit of the trolley wires will open the circuit there, and not open the power-house cir-

cuit-breaker and shut down all other cranes on the line.

In plants having two or more cranes, where the work is not very steady, a generator or transformer having a capacity of one-half kilowatt per ton of crane capacity will be sufficient. Where continuous heavy lifts are the rule, one kilowatt per ton of crane capacity should be allowed. As a crane load is very fluctuating it is not advisable to run it from a circuit which supplies lights or constant-speed motors, on account of the excessive variation in local voltage produced by rapid and wide load changes.

Besides the main trolley wires supplying the whole crane, there are trolley wires along the inside of the bridge frame to supply current to the motors on the carriage, their number depending on the equipment of the crane.

Owing to the many wiring connections on a crane and the opportunities for "grounds" to occur, pilot and ground-detector lamps should be provided on the switchboard in the cage of each crane, in order that, when a ground occurs, each crane operator may, by pulling out his main switch, learn if the ground is on his crane and report it, if found. The lamps being on the line side of the switch, they will not indicate a ground when the switch of the faulty crane is open.

Connections of Crane Motors

Complete wiring diagrams for a four-motor direct-current crane and a three-motor alternating-current crane are shown in Figs. 1 and 2. It will be noted that a single common-return wire is provided for all motors on the carriage and that the bridge motor, being stationary, has no trolley wires but is connected directly to the controller in the cage. In connecting up the controllers care should be taken that the direction of motion of the hook, carriage and bridge corresponds in each case to the direction of throw of the controller lever to which the machine responds.

Hoist Brakes

Some provision is necessary to hold the load when the hoist motor is stopped and to prevent racing when it is lowering. This is sometimes done with worm gearing, but oftener with some type of brake, the commonest form consisting of a cone or band brake, applied by a spring or weight and released by a solenoid or magnet coil which is energized when the controller is thrown to the first notch. The solenoids of direct-current and single-phase series-wound motors are connected in series with the motor, but with polyphase induction motors the solenoid is connected directly across two of the three main leads and receives the full line voltage. These brakes also hold the load in case the supply currents should fail. Even when the motor is worm-geared or equipped with a mechanical load brake, the electro-mechanical brake is a valuable auxiliary, as it brings the motor quickly to rest and makes it unnecessary to reverse while the motor is in motion.

A form of mechanical load brake which is in extensive use is shown in section in Fig. 3 and disassembled in Fig. 4. This brake is mounted on the shaft which drives the drum gearing; this shaft is cut in two and the adjacent ends of the halves project into the drum of the load brake and are fitted with a coupling. The halves of this coupling are not rigidly connected, but are separated about 8 inches and coupled through the medium of a heavy bronze spring, the outside of which is turned to fit the inside of the brake drum and the inside bored to receive a supporting sleeve which prevents the collapse of the spring.

The outside of the brake drum is ribbed in order to increase its cooling surface and has a ratchet on one end to prevent its rotation when the hoist is lowering the load.

The action of this brake is as follows: When the motor turns in the direction for hoisting, the torque exerted on the bronze spring tends to unwind it, causing it to expand and grip the drum, which is free to rotate in this direction and turns with the shaft. When the motor is stopped the load still keeps the spring expanded against the drum, and the load is held by the ratchet on the end of the drum. In lowering, the motor tends to wind up the spring, thereby contracting it and allowing it to rotate freely within the drum, which is driven by the weight of the descending load or of the block and cables. The instant that the motor stops, the least movement of the load expands the spring and applies the brake.

All hoist motors should be protected by limit switches arranged to cut off the supply current when the block approaches the drum, otherwise the gears may be stripped and other damage done by a careless operator allowing the block to strike the drum.

Care of Motors

A close watch should be kept on the motor bearings; when they become slightly loose the unbalanced pull on the armature rapidly makes them worse, until they become so worn as to allow the armature to strike the pole-faces, unless the looseness is corrected in time. Direct-current crane motors are usually of the series-wound railway type and often have plain brass bushings for bearings. These wear very rapidly in dusty surroundings, but may be made to run longer by adding a few more turns of wire to the upper field-magnet coils. This takes much of the weight of the armature off the bearing sleeves and thereby increases their life. If there is no room for extra turns on the field-magnet spools, new coils may be made of square wire having the same cross-section as the old round wire. This will give room for about 20 per cent. more turns of wire in the same space. This arrangement, however, has the disadvantage that it is liable to cause sparking at the commutator if the field strength is unbalanced very much.

Many crane motors are of the consequent-pole type, having only one field-

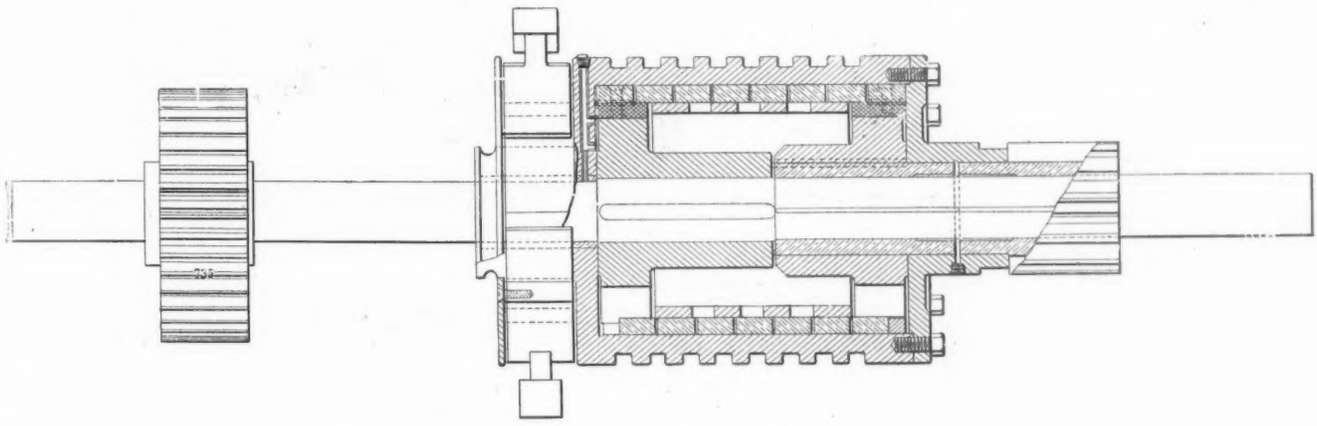


FIG. 3. DRUM-TYPE LOAD BRAKE

magnet coil for each pair of poles, and the armature winding is either cross-connected or wave-wound, so that only two brushes 90 per cent. apart are required on a four-pole machine.

Sparking at the commutator may be due to dirt, loose brushes, an untrue commutator, loose bearings, an open circuit in the armature or a burned-out field-magnet coil. Loose brushes and poorly-fitted brushes both have the same effect; if loose in the holders they wear two facets, becoming V-shaped on the faces, due to the reversal of the motor; in this condition they fail to cover a large enough arc of the commutator, and this causes bad commutation. The sparking due to an open circuit is very easily identified, as it differs from that due to any other cause. A vicious spark occurs at each revolution and the commutator is pitted and the mica burned out between the segments to which the open-circuited coil is connected. In most makes of crane motor there will be two burned spots directly opposite, one for each direction of rotation. If the commutator is untrue and the brushes wear until the holders are down on the stops, a flash will result at each revolution, due to the brush breaking contact with the commutator when its "low" side comes around.

Repeated overloading will sometimes char the insulation of the field-magnet coils and the current will leak from layer to layer, weakening the field and decreasing the torque, but increasing the speed and causing severe sparking. If only one coil is defective it may be located by its being cooler than the good coils. To test the field-magnet coils properly they should be removed and if the insulation appears all right their resistance must be measured and compared with that of a similar coil, known to be good. An easy way to do this is to connect the doubtful coil in parallel with a good one, putting an ammeter in series with each. If the currents through the two coils are considerably different, the coil which passes the strongest current is the defective one.

Care must be used when replacing field-magnet coils to connect them up for the proper polarity. In a motor of the consequent-pole type it is especially easy to make incorrect connections; the two coils must be connected to produce the same polarity at the magnet pole-faces, which will cause the formation of two consequent poles on the small pole-faces cast between the other two. If the two field-magnet coils are connected for different polarities no intermediate consequent poles will be formed, and the field magnet will be of the bipolar type; the armature will not turn until the connections are changed.

Spare armatures for all crane motors should be kept on hand, and in installing several cranes the motors should be selected, if possible, so that one spare armature will fit several motors. When an armature coil is damaged and no spare armature is at hand, a temporary repair may be made by bridging the commutator segments connected to the faulty coil and cutting off the terminals of the coil close to the armature core.

All the wiring should be kept free from grounds; if it should happen that two crane motors become grounded on different sides of the line, neither one alone will cause any trouble, but if the two motors should be started at the same time a violent short-circuit will result.

Small circuit-breakers (up to 120 amperes capacity) can be purchased for about $6 each, and it is strongly advisable to use them in the cage instead of fuses, which are very liable to be replaced by copper wires if they blow frequently. A circuit-breaker should be provided for each motor and also a main circuit-breaker for each complete crane equipment.

If a coil should burn out in the controller, the motor will not start until the traveling contact has passed the connection to the defective coil; it will then start with a violent rush and probably blow the fuses. The controller may be temporarily repaired by bridging the two contacts to which the burned coil is connected, but the coil must be replaced at the first opportunity. Few crane controllers are designed for continuous duty, and in order to avoid overheating the resistance the motors should be run at full speed whenever it is practicable.

Most of the troubles mentioned apply to direct-current crane motors. No mention has been made of the repair or care of alternating-current motors because they seldom give any trouble, and what few troubles they are subject to have been mentioned in the previous article on "Variable Speed Polyphase Induction Motors," published in the issue of June 9, 1908. The remarks concerning brakes, circuit-breakers and other auxiliaries apply, of course, to both direct- and alternating-current equipment.

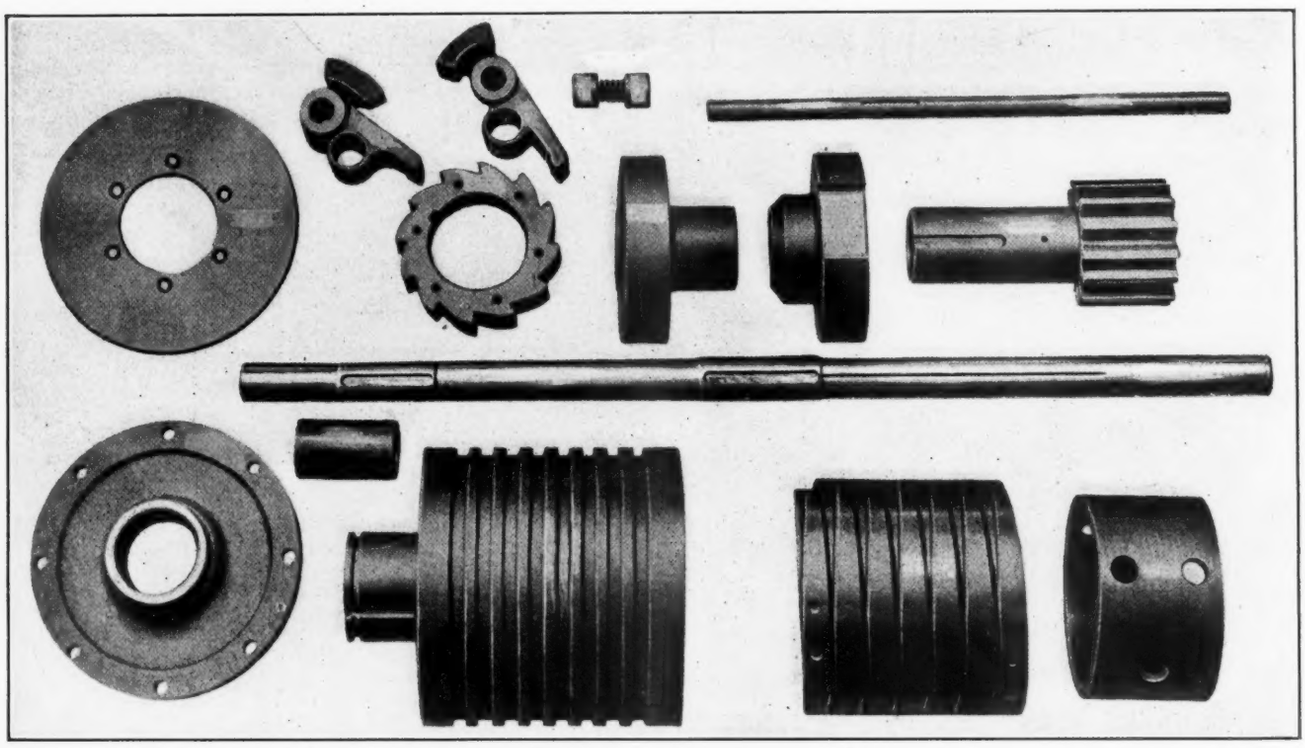


FIG. 4. COMPONENT PARTS OF DRUM-TYPE LOAD BRAKE

A Heating System Utilizing the Waste Heat of a Gas Engine

By F. C. Tryon

There is a prevailing idea, and one which has prevented the adopting of gas power in many instances, that with a gas-power plant of any kind a separate and distinctly different heating system must be installed—one with which the power plant will have no connection; that additional service and attention will be necessary and additional fuel provided, so that the saving shown in cost of fuel between a gas-power plant and a steam installation in which the exhaust steam will provide the necessary heating medium will be nearly or completely offset by the extra fuel and service required by the special heating equipment. This supposed lack of a reliable heating system auxiliary to a gas-power plant has doubtless been the deciding point in many instances where gas power has been seriously investigated and favorably considered, but finally abandoned in favor of steam. Nearly all users of gas engines have been looking for some practical manner of utilizing the waste heat of their plants for heating their buildings during the cold months. Many systems have been tried that have been more or less successful or troublesome, but none that has been so completely satisfactory that the user felt like recommending it to his neighbor, until one used during the past winter by a large manufacturer in western Pennsylvania was devised. The entire power of this plant is supplied by gas engines and a new factory building just completed had to be provided with some kind of a heating system; the result of this need was the system herein described.

Construction of the Apparatus

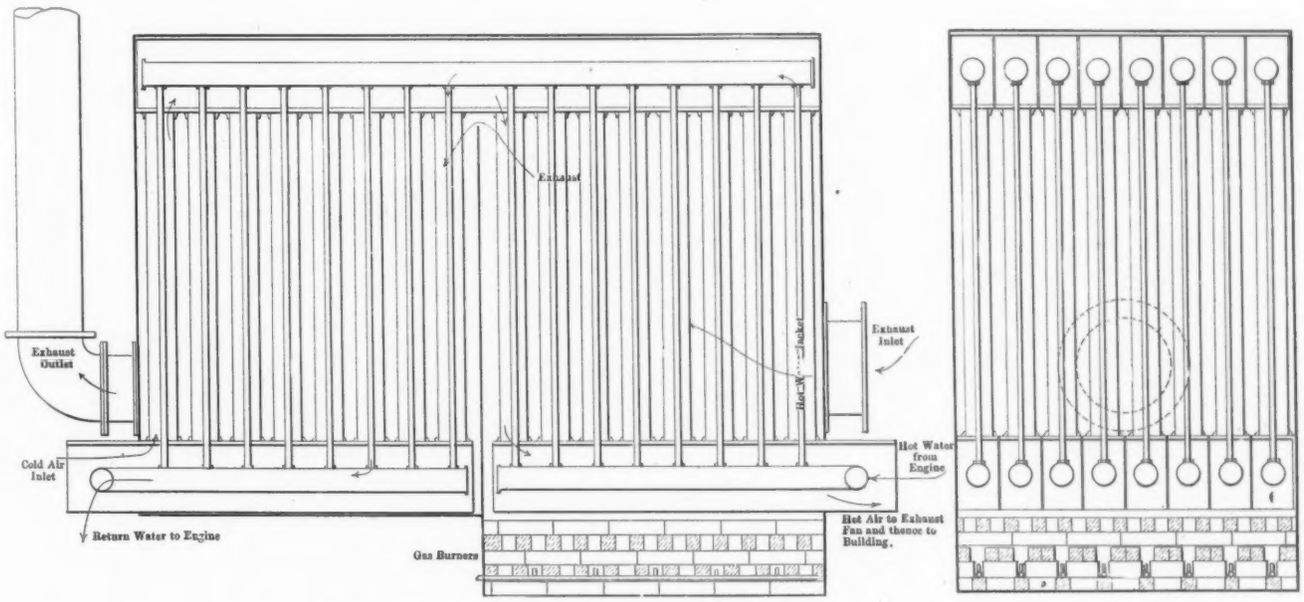
The heating apparatus was built up of several sections of headers, or manifolds and pipes, each section consisting of a long top manifold and two shorter ones at the bottom, each of the shorter ones having one-half the number of side outlets provided in each of the long ones. Four-inch pipes 4 feet long, arranged vertically 2 inches apart, connect one long manifold on top to two short ones at the bottom. On the inside of these three manifolds are others of smaller diameter which are connected together by 1-inch pipes passing centrally through the 4-inch pipes. The two short manifolds at the bottom into which the 4-inch pipes are screwed project at the outer ends beyond the ends of the long top manifold; one of these projecting ends opens to the atmosphere and the projecting end of the other short manifold is connected to a duct leading to an exhaust fan. The accompanying sketch shows the construction of one section of the piping. Several of these sections are placed side by side as close as possible and inclosed in a housing. A vertical partition in this casing is located between the two short bottom manifolds; this partition separates the housing into two equal compartments and the extended ends of the short manifolds project through each side of this housing near its bottom.

One of the small manifolds into which the 1-inch pipes are connected receives the warm water from the jacket outlet of the engine and the other short manifold of the 1-inch pipes is connected to a circulating pump which forces the water, now cooled to atmospheric temperature, back to the jacket-water inlet of the gas engine. The exhaust gases of the engine are delivered into one compartment of the housing, passing between the pipes of the outer manifolds in that compartment and over the top of the partition which separates the housing into two compartments, into the other compartment from which the gases are discharged near the bottom into a vertical exhaust pipe leading to the atmosphere. Valves and by-pass pipes are provided to carry the exhaust gases directly to this vertical exhaust pipe when desired. An exhaust fan or blower driven by a separate small gas engine draws air through the two banks of large-pipe manifolds and delivers it to a distributing system carrying the heated air to registers throughout the building.

Operation of the Heater

The operation of this heater is almost obvious. The hot jacket water from the engine passes through the inner small-pipe manifolds, delivering heat to the air which is drawn through the outer manifolds in the opposite direction. The exhaust gases passing through the housing also give up heat to the air manifolds. The fresh air for heating purposes is drawn in from the outside atmosphere and passes through the manifolds in a direction opposite to that of the hot water and gases; consequently, the cold air first comes in contact with the coolest parts of the heating system, giving a true counter-current effect.

The small blower engine runs nights and Sundays, keeping the buildings slightly warmed even when the larger engine is not in operation. For emergencies, however, there is provided under the housing of the first compartment a nest of checker fire-bricks and a number of gas pipes arranged as burners. In excessively cold weather or when the building has been closed and it is necessary to heat it before the large engine starts in operation, gas can be turned into these burners



SHOWING CONSTRUCTION OF GAS-ENGINE WASTE-HEAT HEATER

and the air heated by them to almost any temperature desired.

The discharge water leaves the engine jacket at about 120 to 150 degrees Fahrenheit, and the exhaust gases leave the engine at from 600 to 800 degrees Fahrenheit; consequently the exhaust gases in the first compartment of the heating system are much hotter than the jacket water in the pipes of that system, but the volume of air that is passing between the hot water and the hotter gases will absorb this heat. If the air should become hotter than the water near the water inlet and air outlet of the heater, some of the heat of the air might be transmitted to the water, but the colder air near the air inlet and water outlet should absorb this heat effectually before the water is returned to the engine.

The heating plant herein described has proved so entirely satisfactory that its adoption is recommended to all users of gas engines. The entire cost of installation is but little more than it would be necessary to expend in putting in the necessary pipe valves and fittings for a direct-heating system using the exhaust steam from a steam engine.

Twenty-five gallon degrees equal one ton of refrigeration-brine, 1250.

A Boiler Washing and Filling System

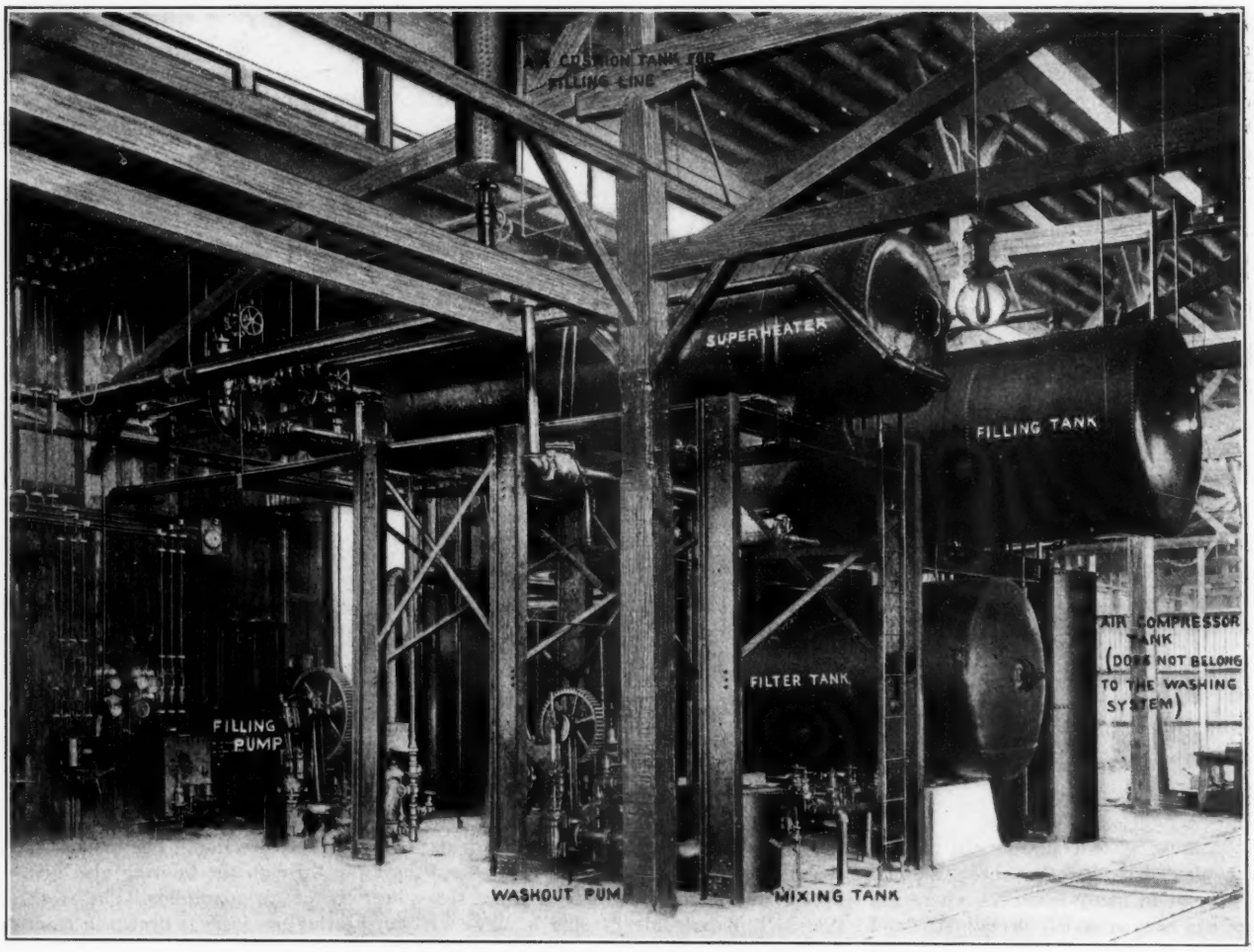
By Ethan Viall

The Wabash railroad recently installed one of the most complete and efficient locomotive boiler-washing and filling systems in the country. This plant was put in at the roundhouse in Decatur, Ill., and was to some extent modeled after a similar one in Moberly, Mo. The original washing system was outlined by the Erie Heating Company and was expanded and developed by W. A. Hoskins, electrical engineer of the Wabash, who also had charge of the Decatur work, and as a consequence most of the faults discovered in actual use at Moberly have been eliminated at Decatur.

The system comprises a number of tanks, pumps and the necessary piping and connections. The roundhouse has forty-two stalls, each of which is connected in such a way with the system that an engine may be blown off or filled in each stall. In addition to this, fifteen of the stalls have hot-water-boiler washing connections.

In washing out a boiler, all lime or mud is removed in such manner that the boiler is not chilled in any way during the operation. An engine usually enters the stall with about 150 pounds of steam on. It is run into a stall and blocked, the blow-off line is connected to the water-leg of the engine and the steam in the boiler forces the water and steam into a washout tank which is so arranged that the steam and water are separated, the steam going into a separate tank where it is condensed for filling purposes. The mud and water go into a lower tank, where the water is filtered for further use. The temperature of the water in this lower tank varies from 140 to 200 degrees. This water drains off into another tank which is automatically controlled by a thermostatic valve which admits enough cold water to reduce the heat to 120 degrees, this being the maximum temperature of the water used in flushing out the boilers. This temperature is kept very uniform, so that the utmost protection to the boiler is obtained in washing out the hottest locomotive.

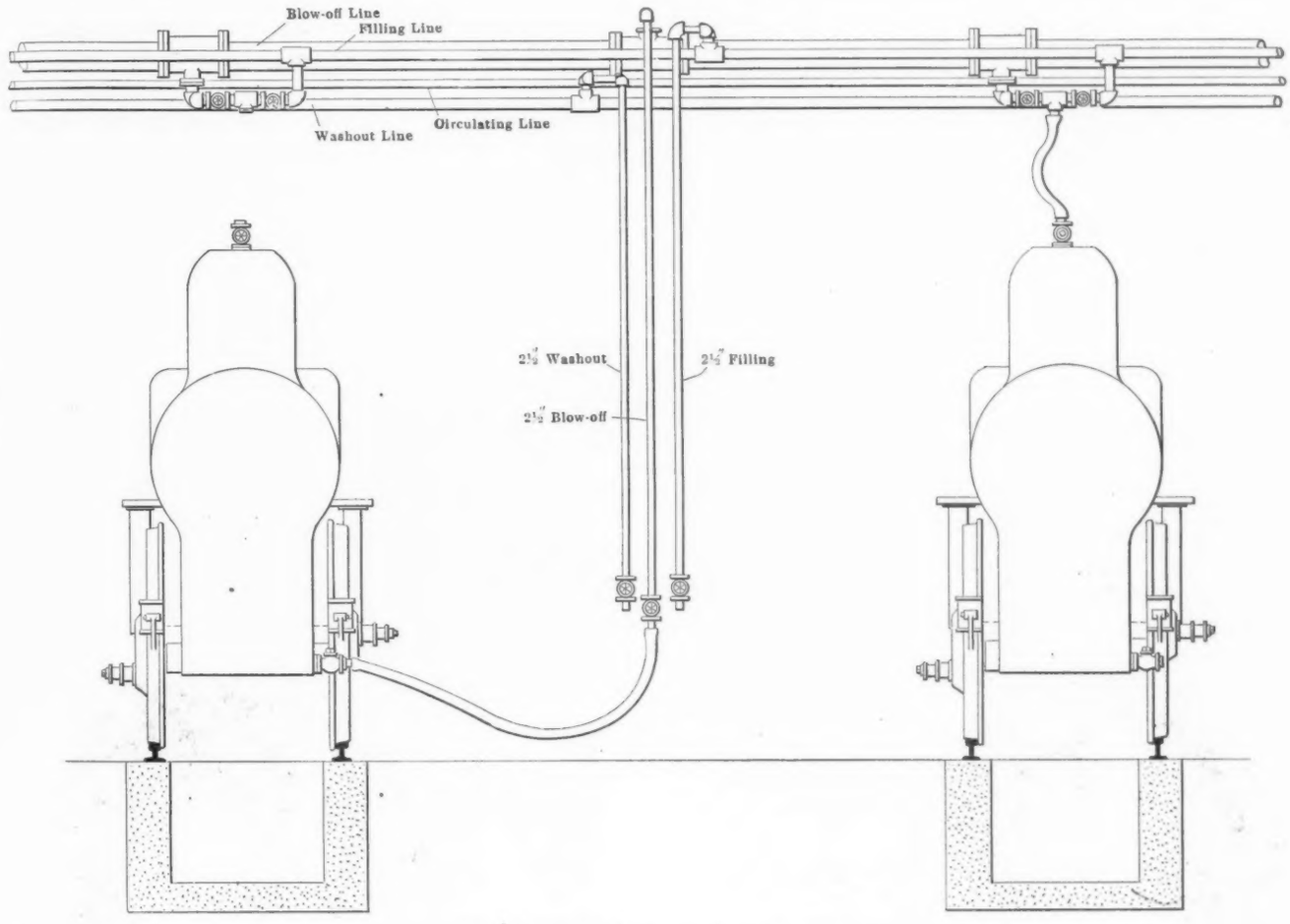
Triplex pumps, motor-driven and automatically controlled, maintain an even pressure of 80 pounds on each of the washout nozzles, regardless of the number being used. These pumps are capable of pumping 350 gallons a minute. The mere



BOILER WASHING AND FILLING APPARATUS

turning of a valve in the roundhouse automatically starts them.

After a boiler is washed out it is filled with water taken from the tank shown in the upper right-hand section of the photograph. This is distilled water, kept at 180 degrees, and on its way to the engine it passes through the superheater (shown at the left of the filling tank) which is jacketed with live steam, by means of which the water is raised to a maximum of 320 degrees, which gives a pressure of about 100 pounds. In this way sufficient pressure is secured to work the blower of the engine, or to move it, if needed.



SHOWING CONNECTIONS IN ROUNDHOUSE

The filling pumps also have a capacity of 350 gallons a minute and a boiler pressure of 175 pounds can be secured. About ten minutes is required to fill a boiler by this system, while the old way took from half to three-quarters of an hour.

Perhaps the most interesting feature, from an engineer's standpoint, is the fact that in case of the boiler being clogged with mud or foaming, it is so arranged that water in the boiler may be removed and the boiler refilled in twenty minutes without drawing the fire under the boiler. With this system it is also possible to take the largest locomotive now in use, blow it off, wash it out, fill it again and put 100 pounds of steam pressure in the boiler in one hour and three-quarters, and there is absolutely no danger to fire-box or boiler from unequal expansion. With the old-fashioned method of boiler-washing, still used in most roundhouses, it takes from five to nine hours and the rapid and uneven cooling is both risky and expensive.

Under the old plan all water from the boilers was run into the sewer, but with this system 66⅔ per cent. is estimated to be saved.

A 25-horse-power motor is used on the filling pump and 15-horse-power on the washout pump. The power used is obtained from a 400-volt alternating current from the car shops, which is stepped up by means of static transformers to 7500 volts. This is run through the yards by the Wabash's own lines to a step-down transformer at the roundhouse, where the voltage is reduced to 480. It is then used to operate not only the boiler-washing system, but also the air compressors, turntable, Gantry crane and the machinery in the repair shop. There is also another transformer which reduces current from 480 to 110 volts for lighting purposes.

The new shops and roundhouse, as well as everything else, are operated by electricity and this is probably the only railroad-yard unit so operated in the country.

Wisconsin Water Power

Prof. Leonard S. Smith, of the University of Wisconsin, civil engineer for the Wisconsin Geological and Natural History Survey, has investigated Wisconsin's water powers and his findings will soon be published in bulletin form. Six hundred miles of rivers were surveyed and daily measurements of the flow of the principal streams, covering six years, have been made.

The professor states that probably not more than half a dozen States are as favorably situated, with reference to water powers, as Wisconsin. The total water power now developed is calculated as 130,000 horse-power, but this is only a small proportion of that available. One plant being installed on the St. Louis river, near Superior, will develop 200,000 horse-power, making it second to the great plant at Niagara.

Hydraulic Turbine Wear and Corrosion

Results of an Investigation of Abnormal Wear, Abrasion and Corrosion of Water Turbines, with Views of Corroded and Pitted Vanes

BY EDWARD P. BUFFET

An investigation of abnormal wear, abrasion and corrosion of hydraulic turbines has been made by Julien Dalemont, professor at the University of Freiburg. The results are published by *L'Eclairage Electrique*, Paris, in a pamphlet of some 60 pages with numerous illustrations of

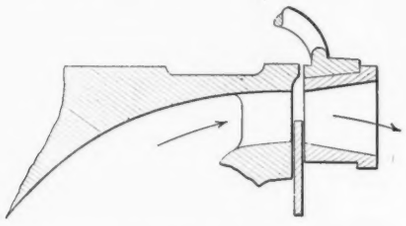


FIG. 1. AXIAL SECTION OF 1200-HORSE-POWER REACTION TURBINE OF 300 R.P.M.

corroded and pitted turbine vanes, etc. We present the discussion in abstract, as follows:

Abnormal wear, tear and corrosion of turbines are of two kinds, the accidental and the localized but gradual. The former comprises such breakages as are caused by large solid bodies, and it is to the latter that the present discussion relates. Evidently a stream of liquid moving in a particular manner will impart its

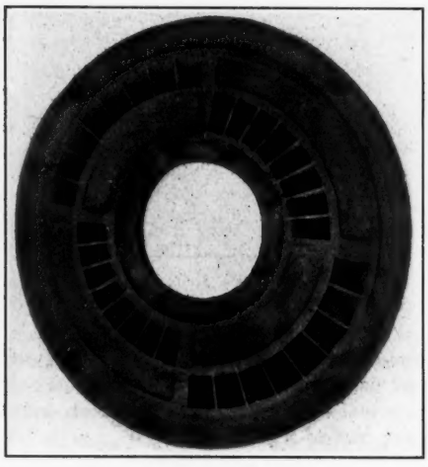


FIG. 4. ENTRANCE SIDE OF DISTRIBUTOR OF 200-HORSE-POWER TURBINE

motion to the sand, etc., that it carries, with great uniformity, and the several vanes similarly situated will be worn alike. Erosion is greatly influenced by the methods of feed and regulation, also more or less by the difference between "free-deviation" (impulse) and "limit" (reaction) turbines. Observations were made on four turbines, as follows:

At a certain plant observations were first made on a 1200-horse-power centrifugal reaction turbine of vertical axis, making 300 revolutions per minute. The turbine was provided with a suction-tube, formed nozzles and vanes hollow to give them a special shape. It was regulated by a cylindrical gate moving axially between the guides and wheel, which, when partly closed, interrupted the flow from all the

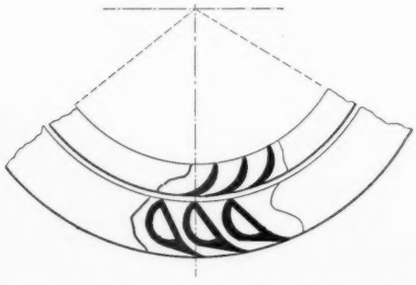


FIG. 2. TRANSVERSE SECTION THROUGH SAME TURBINE

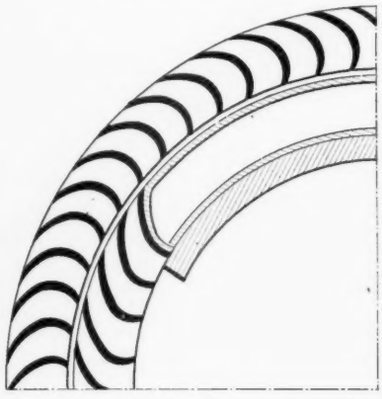


FIG. 5. SECTION OF 300-HORSE-POWER IMPULSE TURBINE

nozzles around the circumference, uniformly. See Figs. 1 and 2. The turbine was used for driving an alternator, and for convenience will be designated as No. 1. Upon examination abnormal wear was noted.

At the same plant a 120-horse-power impulse turbine, with vertical axis, making 600 revolutions per minute, running at part gate, and driving exciters, was examined. The turbine, which will be designated as No. 2, ran without a suction-tube and was fed through two diametrically opposite orifices, Fig. 3, regulated by a gate, or gates, by which the section of the jet was modified with the load, or at least was not sharply broken. No wear.

At another plant turbine No. 3 was of the horizontal-axis impulse type of some 200 horse-power and revolving at 800 revolutions per minute. The feed was

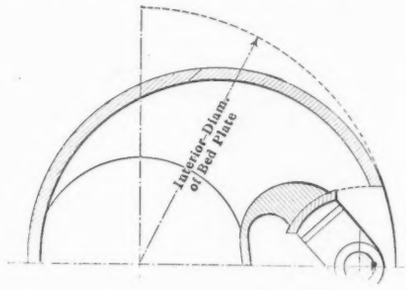


FIG. 3. ADMISSION ORIFICE OF 120-HORSE-POWER TURBINE

axial and the turbine was provided with a suction-tube. The distributor, Fig. 4, contains orifices arranged on the entrance side in four quadrants and alternating in two concentric rings, but all merging on the side adjacent to the wheels into a single ring of blades. The regulating device was a flat gate placed at the entrance to the distributor and arranged to close a greater or less number of the orifices

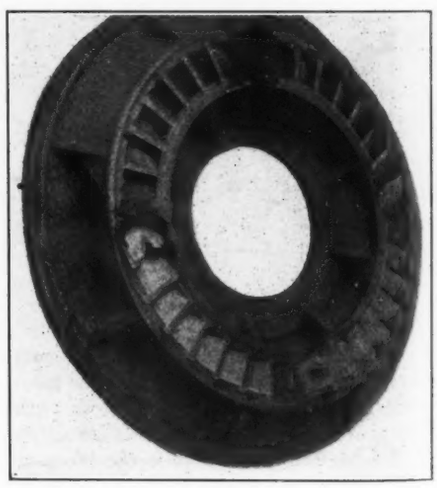


FIG. 6. EXIT SIDE OF DISTRIBUTOR OF FIG. 4

comprising each quadrant according to its displacement around the shaft. Erosion took place.

At a third plant turbine No. 4, which was rated at 300 horse-power and had a speed of 330 revolutions per minute, was of the centrifugal impulse type, with-

out suction and with partial admission regulated through the successive closure of several guide entrances by arc-shaped gates, see Fig. 5. Thus the feed through certain guide orifices was suppressed without modifying the form of jet from the

FIG. 7. EXIT SIDE OF TURBINE WHEEL OF FIG. 4

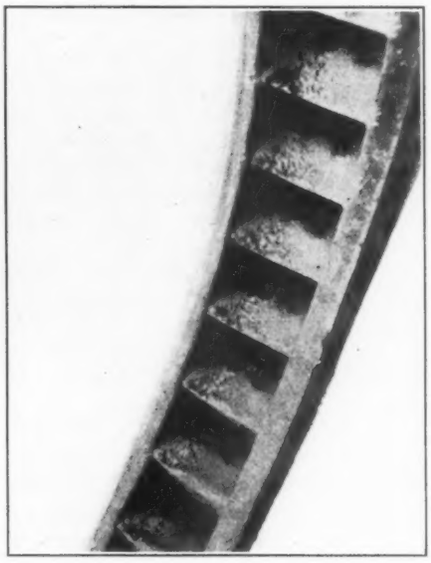


FIG. 8. ENTRANCE SIDE OF TURBINE WHEEL SHOWN IN FIG. 1

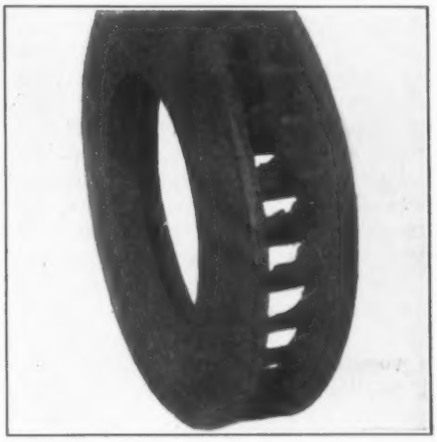


FIG. 9. DISTRIBUTOR OF REACTION TURBINE SHOWN IN FIG. 1

others. Condition excellent after eight years.

By a comparative study of these turbines it was inferred that the localized erosion is influenced by the method of regulation. Broken streams or those rapidly changed in section, or in direction and section, form eddies. Suction would be likely to produce the same sort of effect. It was found, however, in cases where suction has been abandoned, that erosion persisted. The arrangement of the guides must be responsible, in part at least, for erosion. Variations of load are, of course, another factor.

Mr. Dalemont proceeds to discuss in detail the free-deviation or impulse turbine designated as No. 3, pointing out that the entrance side of each distributor, Fig. 4, where the gate is placed, does not show sensible erosion, or corrosion, while the blades at the exit side, Fig. 6, adjacent to the wheels, are strongly attacked at four symmetrical points. This cannot be charged simply to the suction. The special arrangement of distributor apertures in quadrants forming two concentric rings at the inlet which converge at the outlet into a ring of mean diameter, evidently gives rise to vortices that cause the injury, whether by chemical action or by sand in suspension. In each wheel itself, there is a difference in nature of the wear on the two sides. Toward the distributor it is deeply worn, while on the farther side, Fig. 7, a little localized wear is distinguishable on the back of each blade.

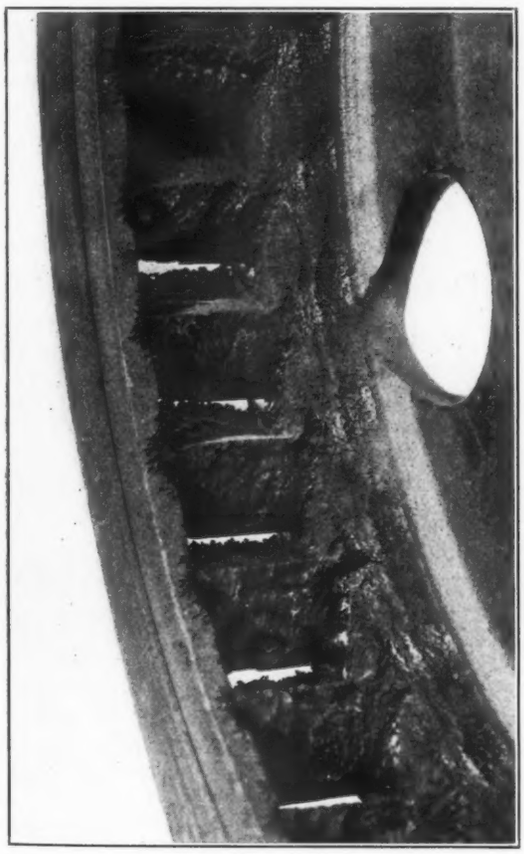


FIG. 10. ENTRANCE TO BLADES

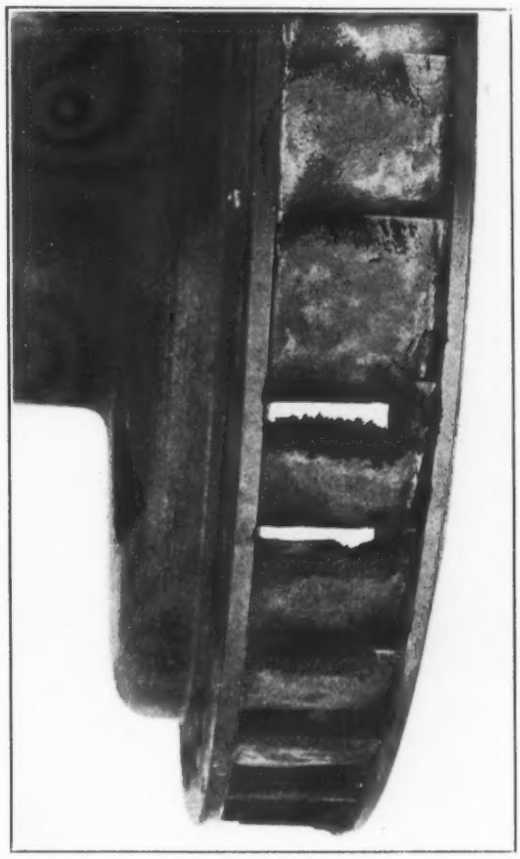


FIG. 11. OUTLET EDGES OF BLADES

Moreover, the interior and exterior walls holding the blades display corrosion or erosion.

Returning to the No. 1 turbine, it was observed that the edges of the wheel blades next to the guide vanes were well preserved, but the backs showed spots of corrosion. The position of the edges in best condition was that along the side shielded by the gate when partly closed, as may be seen in Fig. 8. On the outflow side of the wheel some damage was noted where the neighboring blade does not form a shield, yet the edges are preserved. The corroded parts look pitted and spongy, as if they had been subjected to chemical action. The author cites another writer to the effect that such corrosion in a reaction turbine may result from the formation of an empty space or, to speak more accurately, a region outside the normal current and always full of eddies.

To determine whether such eddies did their damage directly or by a secondary chemical action, there was substituted for the reaction wheel an impulse wheel, the vanes of which were formed of a simple wall varying in thickness and notably differing in curvature from the original blades. This decreased the corrosion, but did not eliminate it.

It was evident that the chemical action of the water, irrespective of application,

FIG. 12. REACTION WHEEL OF BRONZE, OUTLET SIDE

could not be held responsible for the corrosion of this turbine, since another at the same plant has sustained prolonged use without such damage. Moreover, the chemical action would seem likely to operate especially in the place behind the partly closed gate sheltered from the main current, whereas this protected region was seen to be the one where damage did not occur. The facts in this case tended to support the supposition that wear appears more especially in turbines where the stream is distorted, and generally in the path of a current or its immediate vicinity. Changes in direction, velocity, etc., cause eddies, which may be regarded either as accessory to or as virtually parts of the main current. It is hard to deduce a consistent rule from all that Mr. Dalemont tells us as to localities favorable to erosion or corrosion, as he discusses a variety of effects in particular cases without attempting to draw sweeping inferences.

It may be added that the guides of turbine No. 1 were worn away near the wheel at the part where the stream was not cut off by the gate, and that this destruction proceeded from the back side of the vanes, as shown in Fig. 9.

In another plant was an equipment much like the foregoing, of 1200-horsepower centrifugal turbines making 500

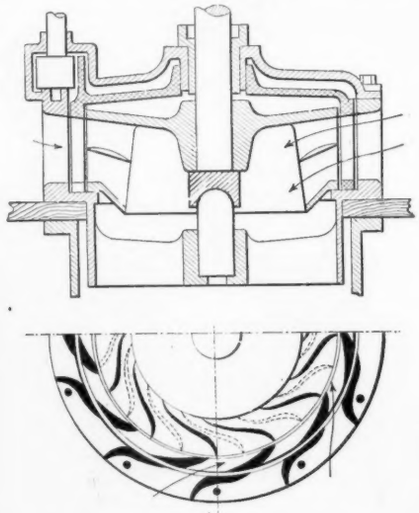


FIG. 13. FRANCIS CENTRIPETAL TURBINE

revolutions per minute. The wheel was fed all around the inside of the buckets, and a cylindrical regulating gate was interposed between the wheel and the guides. The axis was horizontal. The water contained much sand, and in a few months the vanes of one of the turbines were almost unrecognizable. Effects of the gate were not visible, but the backs of the blades were deeply grooved, while the faces struck by the water at its entry to the wheel were relatively well preserved. The outlet edges were destroyed, Figs. 10 and 11 showing the inlet and outlet sides respectively.

Experiments were made on these turbines with a view to prevent the rapid destruction by substituting for the reaction wheel an impulse wheel. Further, the cast-iron wheels of either type were replaced by similar ones made of bronze, which reduced the corrosion, but did not obviate it wholly. It is noteworthy that while the damaged surfaces of iron were complexly striated, those of bronze were smooth, Fig. 12. Two references might be drawn: (1) That the action is not simply chemical; (2) that the mechanical effect on a fairly homogeneous metal like bronze is different from that on one of complex composition such as cast iron.

A section is devoted to the discussion of corroded Francis centripetal turbines. One

FIG. 14. GATE OF FRANCIS TURBINE

of them was regulated by a simultaneous pivoting of the guide vanes. The wheel was of steel and the corrosion, in contrast to that of iron and bronze, took the form of pitting, with little indentations close together which destroyed quite a thickness of metal. The damage to the vanes seemed to have begun in the part of each vane at the entrance against which the current impinged. It was there that the greatest distortions of the stream and most violent eddies would naturally exist as a result of the convergence of the stream by the guides. In another Francis turbine regulated by a revolving cylindrical gate, Figs. 13 and 14, containing orifices made by vanes of special section which modified the streams in the buckets, corrosion of the wheel was trifling, and since the turbine had a suction tube, this fact tends to exculpate such an appliance. Such wear as was detected was most obvious on the side walls near the outlet. The formed blades of the gate itself, however, were much worn.

In the Pelton wheel, where a row of nozzles is placed at one particular part of the periphery, the direction of impingement of the jet on the buckets changes with the rotation of the wheel, and hence, despite the high pressure, there is little localized wear. On the other hand, the distributor, from which the water flows in an invariable direction, is liable to corrosion which, in particular, may take place from secondary action at points out of the main current.

Causes of Abnormal Wear

The data presented herewith indicate a cause beyond the mere friction of the water, which would not have produced the

striated appearance of the surfaces. Sometimes the vane is practically intact, being pitted only in two or three places; sometimes it is deeply cut and the wear reaches to the lateral walls. If the cause is the same, the results need not be entirely similar, since they may be modified by circumstances such as the form of the distributor and the differences of loading,

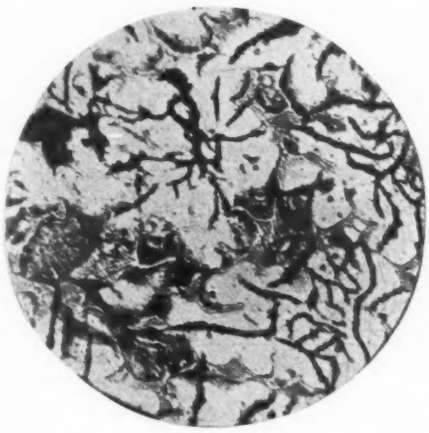


FIG. 15. UNCORRODED BLADE EDGE

but they should carry indications of this common factor.

To search for traces of chemical action, samples from portions of blades corroded and uncorroded were sent to the Royal Laboratory at Berlin for examination. The chief difference between samples from corroded places and those uncorroded was in the quantity of graphite, the explanation of which did not necessarily lie in chemical action. However, it is possible that the chemical reactions took place at such points as to remove certain particles of material by dislocation and

FIG. 16. CORRODED BLADE EDGE

leave the rest intact. The results of analysis are exemplified as follows:

	Parts Not Corroded. Per Cent.	Parts Corroded. Per Cent.
Total carbon	3.40	3.57
Graphite	2.60	2.95
Silicon	1.96	1.91
Phosphorus	1.04	1.05
Manganese	0.44	0.44
Sulphur	0.09	0.09
Iron (by difference)	90.47	89.99

Since the above method was subject to error, samples were sent for microscopical examination to M. Révillon, engineer in the laboratory of Dion-Bouton & Co., at Puteaux. The appearances of the metal at two places were quite different. That uncorroded, Fig. 15, contained much ferrite, phosphide, pearlite and graphite; while the corroded, Fig. 16, still held the graphite, but especially pearlite and phosphide.

The two hypotheses still unsettled in conclusion are: (1) At the point where the eddy is produced, the presence of air and less washing of the surface induce a chemical action. Attempt was made to verify this hypothesis by examination, a polished sample of the blade being subjected to the action of the water for varying lengths of time. But the exposure of the wheel to the air since it was out of service impaired the value of this comparison and the hypothesis in general. (2) The other hypothesis is, that the eddies, acting upon the unequally resistant particles in the iron, would produce local detachments, which effect would be favored by the vibration of the mass. This latter hypothesis refers to mechanical action. The individual particles referred to are especially those of free graphite, and should be the more permanent ones, if we may infer from the results of the chemical and microscopical examinations made by M. Dalemont.

Experiences of a Trouble Man

By R. A. Walkway

The July sun was sending its rays down to "old Mother Earth" with an intensity that presaged a hot day. "Bob" Billings had hardly got his sleeves rolled up ready for work when the superintendent hurried in and said:

"'Bob,' get a move on and go down to Whitney's shop, on Whiskey island, and see what you can do with their engine. They got a dose of water into the cylinder just as they were starting up this morning and have cracked the engine frame so that it won't be safe to operate until it has been fixed."

"Humph! Another case of 'penny wise and pound foolish'. I know all about the place. That's the plant where we put in a feed-water heater about a year ago. You remember, don't you, how Whitney wanted some pointers on reducing coal consumption? They didn't have any feed-water heater, and when one was proposed Whitney kicked on the cost, and it nearly killed him when he finally bought one and installed it. He got 210 degrees heat in his feed-water, instead of letting his exhaust steam escape to the air and the feed-water go into the boiler at between 40 and 65 degrees, according to the time of year."

"How do you make out their last trouble to be 'penny wise and pound foolish'?" asked the superintendent.

"Because Whitney, just to save a few cents, wouldn't put a separator in his steam line. He saved the cost of one all right, but a broken engine frame will take more money to fix than it would have taken to get a separator. Say, ain't it —; well, what Sherman said war was?" and so saying, "Bob" started for the other end of the shop to pack his tool bag.

The trip to Whiskey island was soon made, and entering the office, "Bob" introduced himself and was shown to the engine room. Here he found an old Wright four-valve engine, the frame of which was cracked near the governor, as shown in Fig. 1.

"You won't be able to do much with that frame, will you?" asked the manager of the establishment.

"Oh, I think we can fix things up so you can run the engine for some time to come. It is not as bad a break as I had expected, but a cracked engine frame don't improve its running qualities any."

"No, I don't suppose it does," was the rejoinder. "If that idiot of a fireman had attended to business and had his water down where it belonged, the thing would not have happened!"

"I wouldn't put all the blame on the fireman. I have known of cases where water has been drawn over into the cylinder when it was being carried below the second gage. Why don't you have a separator on your steam pipe?"

"Separators are of no account. My engineer says they won't drain properly only about one-half the time, and the other half they let water pass about the same as if they were not in the steam line. If that is the case, and I think it is, it is money thrown away every time one is bought. I thought of getting one once, but when I went to look over the advertisements of the firms making them I found each claimed that its product would do better work than any other make, and that some were nothing more than atomizers, and another kind would take moisture out of steam after passing through some other make."

"You don't seem to have much use for a separator an' that's a fact," laughed "Bob."

"Not much. I may be wrong, but the claims don't seen to figure out right. Now I think that most of you engineers will admit that one of the claims for exhaust-steam separators is that they will separate the oil and impurities from the exhaust steam, but from what I have seen it would require several of them set in a row, one after the other, before the oil would be removed, and I am of the opinion that where it comes to taking care of slugs of water, the separator holds a little and lets the rest go past."

"You are wrong," replied "Bob;" but I shall not attempt to prove it to you, seein' I was sent here to work and not talk.

However, I am willing to bet the cigars that your engine frame would not have been cracked if you had provided a separator in your steam line. Now let us see how the damage can best be remedied," and so saying, "Bob" put all discussion to one side and set to work.

Repairing the Cracked Frame

First, a piece of 1½-inch rod was obtained and flattened out as shown at *A*, Fig. 2, and a hole cut in it in order to fit it over the governor stand. This piece was threaded at both ends, one being a right- and the other a left-hand thread. Two other rods were obtained, one threaded right-and-left-hand, the other with a right-hand thread on one end and the other end flattened out and a 1-inch hole drilled through it. A hole was drilled in the frame and one in the pillow block, both holes being tapped, one for the 1-inch bolt, the other for the 1½-inch rod. When both rods were in position, the turnbuckles were tightened up and the frame drawn together.

Next, a 2-inch hole was drilled and tapped in the pillow block in a line central through the shaft and a 2-inch rod threaded on both ends, both right-and-left-hand, and screwed into place. Another rod of the same dimension was obtained and one end threaded, the other end being bent in the form of a hook to fit over the rib *B* of the engine frame. When the turnbuckle was tightened up the cracked frame was drawn tightly together. In order to make the rod *A* more secure, a clamp *C* was put in place, which reinforced the bolt holding the rod to the frame. This finished that part of the repair.

As soon as "Bob" had finished his work on this particular job, the engineer said: "I suppose I can start up now, can't I?"

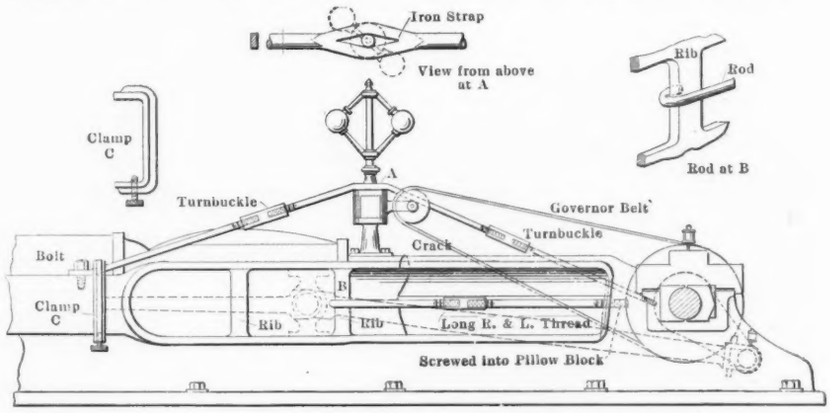


FIG. 2. METHOD OF BRACING THE FRAME

"Start up nothing," replied "Bob." "There is one lesson every engineer should learn early in life, and that is, never start an engine until you are reasonably sure it is in condition to start. Now we don't know whether this engine is damaged in any other part or not, because we only looked for the worst breaks. We will now see if there are any other repairs to make."

So saying, "Bob" began with the valve gear, and went carefully over the engine, step by step. Everything appeared to be all right, but when the crank was reached he discovered that it was crooked very slightly from the edge of the crank-pin part way to the outer edge of the crank. Calling the engineer, "Bob" showed him the crack and at the same time said: "Here is a good example of what might exist with the engine in operation, if a careful search had not been made; and if the crank had let go, as it would some time, there would have been another mystery unaccounted for and everybody would wonder what caused the break."

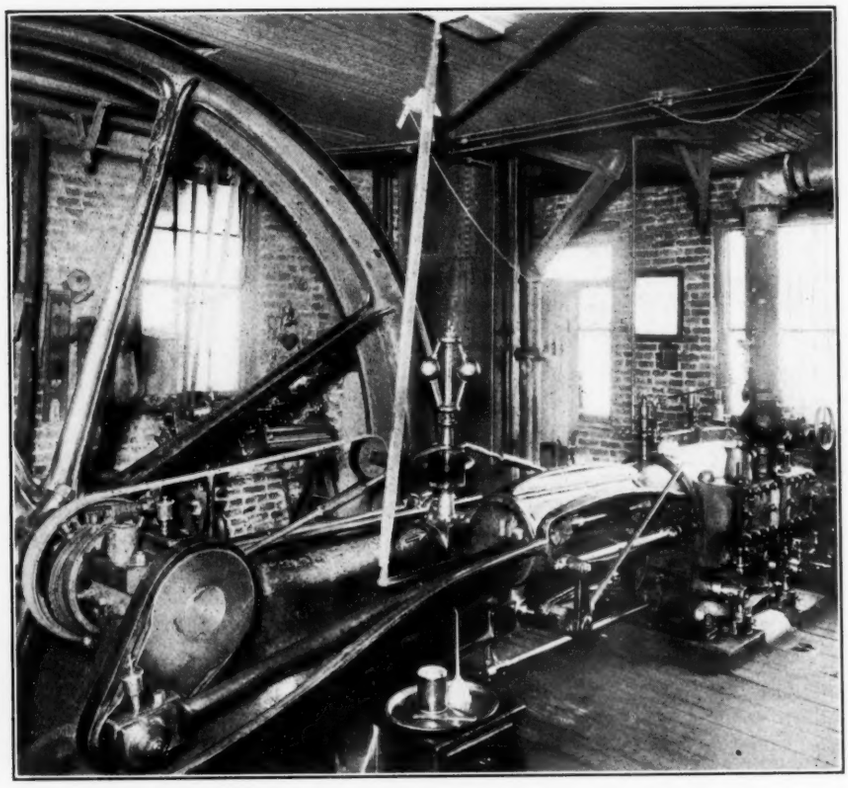


FIG. 1. SHOWING CRACKED ENGINE FRAME AND REINFORCED CRANK

"What seems to be the trouble now?" asked the superintendent, as he came into the engine room from the office. "Why don't you start the engine?" was the next question addressed to the engineer before anyone had an opportunity to answer the first one.

"We won't be able to start the engine just yet," replied "Bob," "seeing the crank is cracked."

"A crack! —— that —— fireman! How are you going to fix that, Mr. Billings? I suppose we'll have to have a new crank, won't we?"

"No. I think I can fix it up so it will answer for some time. We can do that by shrinking on a band around the crank, which will strengthen it sufficiently to carry all the strain it is likely to get here, unless you let more water come over into the cylinder."

The manner of making this repair is shown in Fig. 1, which hardly requires any explanation. The measurement of the crank was taken and a band shaped to fit snugly over it when hot; when cooling, the contraction caused it to fit tightly to the crank. As no other defects were found, the engine was started up, slowly at first, and when it was evident that none of the parts was strained, it was brought up to full speed and the load thrown on.

"You have done a good job," were the parting words of the superintendent, as "Bob" lit his pipe preparatory to returning to the shop, "but I hope I shall not be compelled to call on you again for a similar job."

"Well," replied "Bob," "there is one thing pretty sure, you won't have to if you get a separator on that steam pipe."

Heating and Ventilation of School Buildings

Regulating Temperature; Importance of Location of Registers; Velocity and Volume of Air Required to Insure Healthful Ventilation

BY WALTER B. SNOW

The purity of the air which we breathe is indicated by the number of parts of carbonic-acid gas in 10,000 parts of air. In the open country 3 to 4 parts will be found, but in a closed and crowded room without ventilation the proportion may run up to 30 or 40 in 10,000. A musty odor will be barely perceptible when only 6 or 7 parts are present as the result of respiration. Good ventilation is secured by the presence of not more than 6, and fair ventilation by not more than 8 parts of carbonic acid. It may be readily shown that to maintain 6 to 8 parts in an apartment continuously occupied by a given number of persons, will require a supply of from 3000 to 1500 cubic feet of air per hour per individual.

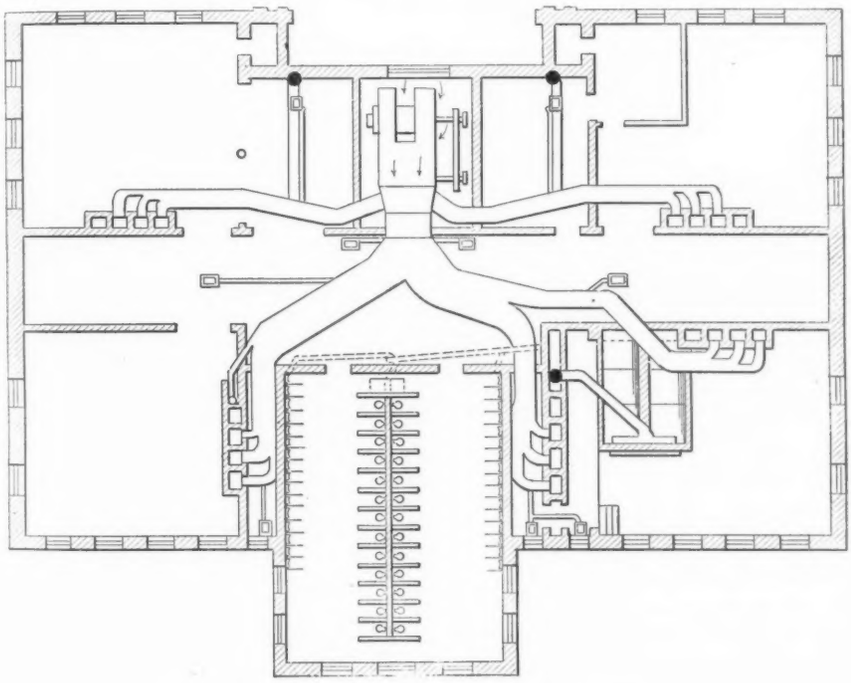


FIG. 1. DOUBLE-DUCT SYSTEM OF INDIRECT HEATING

An ordinary school room containing 56 pupils and teacher would thus hourly require from 171,000 to 85,500 cubic feet, equivalent to passing through the room once in every five or ten minutes a volume of air equal to its cubical contents. On the basis of 250 cubic feet of space per occupant, which is ordinarily provided in a modern school room, this would mean from 25 to 50 cubic feet per minute for each. The usual amount as required by law in many States is 30 cubic feet. At least this amount is necessary to maintain the physical health and mental activity of the scholar.

Temperature Regulation

It is fully realized that to insure the constancy and equality of such supply at all times, positive means must be employed. Hence the fan blower is accepted as the primary element in a positive-acting system, and mechanical ventilation is provided in every well-fitted school building. For satisfactory results the air should be forced into the building. Control is then had over its source and quality. This air must always be heated before it is admitted to the room.

In the simplest application the fan is centrally located in the basement and all of the air is heated by passing over centralized heating surface. From the fan the heated air is forced through pipes to the various rooms. But with this simple, single-pipe system the only means of regulating the temperature of individual rooms is by adjustment of the registers. As a consequence the volume of air admitted is subject to change according to the heating requirements, which not only vary hour by hour, but differ in various rooms.

It is then manifest that to maintain constant and equable ventilation and to provide at the same time for variation in temperature, independent means of regulation must be furnished. In its simplest form this arrangement is provided by a double-pipe system, one pipe conveying heated and the other unheated or tempered air. Mixture of the air from the two pipes is then made at the base of each flue to suit the requirements of the individual room with which it connects.

For the purpose of mixing, various types of damper are applicable. To be suitable, however, the damper must be so designed as to permit of the passage of a practically constant total volume, regardless of the proportions of warm and cool air which make up that total.

System for Indirect Heating

An example of the application of the double-duct system is presented in Fig. 1. A duplex fan is located in the basement as near the center of the building as possible, arranged to draw the air through windows and force it through the heater. Thence it passes through the ducts which are in duplicate, the upper carrying air which has bypassed over the heater, and the lower the air which has been heated by passing through the heater. All of the heating surface except a small amount of direct in the corridors is concentrated in this primary heater. At the base of each flue is a special form of damper, Fig. 2, actuated by a thermostat which is automatically controlled from the individual room with which the flue connects. The cylindrical shape of the damper insures the maintenance of constant volume, for the combined area for discharge from both of the pipes is always the same. Another form is shown in Fig. 3.

The vent flues are provided with dampers at their tops so that they may be closed when the rooms with which they connect are not occupied. An improvement in this system, permissible only when the temperature is thermostatically controlled, consists in carrying individual pipes to each room from a central heating chamber. The manner of applying such a system to a large school building is illustrated in Fig. 4. Here the fan is placed near the center of the building and the air conducted to it from special fresh-air inlets. Before reaching the fan this air passes through a tempering coil by which it is raised to a temperature not exceeding 70 degrees. It is usual to provide this coil with a bypass damper oper-

ated by thermostat so as to maintain practically constant temperature of the air entering the fan. Thence it passes through the fan into the heater chamber. The heaters are raised above the level of the floor so that the air may pass beneath them without further heating, or may be forced through them and thus heated to any desired degree, according to the number of sections in service. From the lower or tempered air-chamber individual pipes pass up and connect with corresponding pipes from the hot-air chamber. At the junction of each pair of tempered and hot-air pipes is a damper under thermostatic control from the room to which it supplies air. By the operation of this damper the air in each pipe is tempered to the exact requirement of the particular room. Any possible difference in volume, due to difference in resistance of various lengths of pipes, is by this system completely overcome as regards the effect of that difference in the temperature of the room.

Still another arrangement of the indirect system is possible. The air is primarily heated or tempered to about the temperature of the room and then passed through a single-pipe system to the bases of the flues. In the base of each flue is provided a supplementary or secondary heater under thermostatic control from the room with which the flue connects. Under ordinary conditions this heater warms the air just enough to make up for losses by radiation from the room. But in warm weather it is automatically shut off altogether and the air is admitted to the room at the temperature originally given it by the tempering coil. As this temperature is usually just about that of the room itself, neither cooling nor heating results—the air merely sweeps through the room.

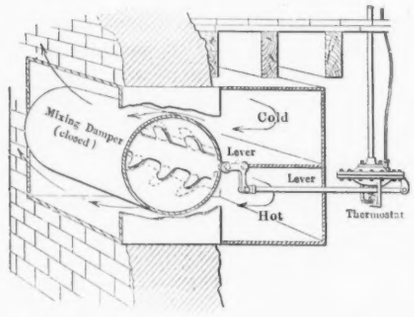


FIG. 2. SPECIAL DAMPER TO INSURE A CONSTANT AIR VOLUME

In some cases direct radiation is provided in the rooms, the supplementary coils are omitted and the tempered air admitted, as in the arrangement just described. This renders the ventilation and the heating entirely independent.

It is not the purpose of this article to go into the details of proportioning a direct heating installation—suffice it to say that the amount of surface provided for each room must be dependent upon the exposure, the relative amount of wall and gas surface and other less important factors.

Location of Inlet and Outlet Registers Important

The indirect system, particularly with the primary and secondary coils massed in connection with the fan, does not, as a rule, call for so great refinement in its design and proportions. If the aggregate amount of surface is sufficient, the equalization of distribution and of temperature within the room are readily secured through the medium of the mixing dampers.

The success of otherwise well-designed systems depends primarily upon the location of the inlet and outlet registers. In a class room, which seldom exceeds 28x32 feet in size, with not more than two and sometimes only one wall containing windows, it is customary to place a single inlet register about 8 feet above the floor in a wall opposite one having windows. The air from the outlet then passes above head-level from the warm toward the cold wall. There it becomes slightly cooled, falls to the floor, and acting in part under the pressure of the continuously incoming and downward flowing air, passes back across the bodies of the occupants to a register in the same wall in which the supply register is located. The vent register is, however, placed at floor-level. An ideal arrangement would consist of a row of inlet and outlet registers which would give a thorough distribution of air. But architecturally this is hardly possible under existing conditions of design.

Velocity and Volume of Air

To avoid perceptible drafts the air should not be admitted at a velocity much exceeding 350 to 400 feet per minute through the free area of the register, and to further avoid inequality of discharge through the entire area of the register, the flue velocity ought not to exceed 600 to 800 feet. When the difference between flue and register velocities is great, there is a tendency toward considerable irregularity in the rate of flow through the different portions of the register. Manifestly, properly to control the air supply for the individual rooms at a distant point in the basement, each room should have a flue entirely independent from the others. The velocity of the air in the branch pipes connecting to the bases of these flues should be kept down to 1000 or 1200 feet per minute, while that in the main pipe of a double-pipe system may range up to 1500 feet or over.

In each case the area to be provided is obviously that which will pass the required volume without exceeding the specified velocity. If the velocity is too high it may cause humming in the pipes and at the registers, with uncomfortable drafts in the rooms.

For accurate calculation, the total volume to be provided by the fan should be determined on the basis of 30 cubic feet per minute per seat in the class rooms, plus the amount to be provided for passages, smaller rooms, assembly rooms, etc. In round figures it may be based on a change once in eight minutes in class rooms, about the same in assembly rooms to be temporarily occupied, and once in 12 to 15 minutes in halls and other apartments. The fan is usually of centrifugal type, in which the discharge is around the

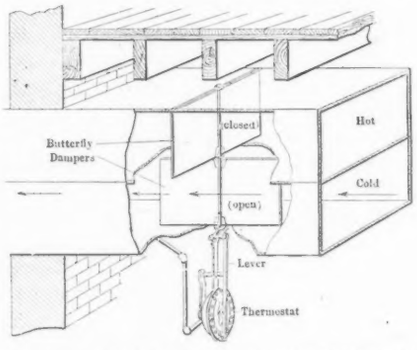


FIG. 3. ANOTHER FORM OF CONSTANT-VOLUME DAMPER

circumference. Although an uncased centrifugal fan of the cone type may be used where the air is to be discharged into large distributing ducts or chambers, the cased type is necessary where the ducts are limited in size and velocities therein range from 1200 to 2000 feet per minute.

Steam pressures for school-house heating ordinarily range from 20 to 40 pounds; at least 20 pounds is necessary if a steam engine is to be provided for driving. But when gas or electricity are to be utilized for power, the pressure may, of course, be reduced, but the lower the pressure the greater must be the area of the heating surface to give the desired result. It should ordinarily be sufficient to heat the air from 0 to 130 degrees.

Heat Loss and Ventilation

In all types of installation except that in which direct radiation is provided in the rooms, the air is of necessity the vehicle by which heat is transmitted to the room. The loss of heat from the building is the result, first, of conduction and radiation through windows, doors, walls, floors and ceilings, and second of the leakage or the intentional escape of air through the vent flues. The escaping air is obviously of the temperature of the room. Through the first medium the rate of loss is proportional to the difference between the internal and external temperatures. The cost of the heat supply to make good this loss is measured by the difference between the average temperature of the air within the room and that of the air entering through the register. On the other hand the loss of heat in the escaping air is, as in the above case, measured by the temperature difference be-

tween indoors and outdoors. This loss is unavoidable where ventilation is intentional, and is proportional to the degree of ventilation, i.e., to the rate of air change. But the more frequent the air change, the less the temperature of the air need be to bring into the room a certain amount of heat in a given time. For instance, with a sixteen-minute change, an entering temperature of about 140 degrees is necessary to maintain 70 degrees within an ordinary building with zero temperature outside. If, however, the frequency be increased to once in eight minutes, as is represented by good school-house practice, the temperature of the entering air need not be so high. The real heating power of the air is measured by its temperature above 70 degrees, namely, 140 minus 70 equals 70 degrees in the former case. With double the air admission to provide an eight-minute change, only one-half the temperature increase, or 35 degrees, will be required. Hence under the latter condition the temperature at the register need be only 70 plus 35 equals 105 degrees.

Such calculations are necessarily approximate but sufficiently close to give an idea of the conditions and of the effect of change in the volume of air admitted.

Because the temperature is lower it must not be supposed that the total amount of heat is less with the more rapid air change. Although the temperature is lower, the volume is greater. With the sixteen-minute change the total heat may be represented by the radiation and conduction loss of 70 units plus the leakage loss of 70 units, if the term may be so used for purposes of comparison, making a total of 140 units. When the volume per minute is doubled by changing the air once in eight minutes, the radiation and conduction loss remains the same, namely, 70 units, but the leakage loss becomes 2 times 70 equals 140 units, and the total loss is 70 plus 140 equals 210 units, or 50 per cent. greater than in the first instance.

The cost of ventilation is thus clearly evident. It cannot be avoided if ventilation is to be provided, but only in so far as ventilation is recognized as a necessity will the cost of securing it be regarded as a proper and legitimate expense in connection with a system of heating.

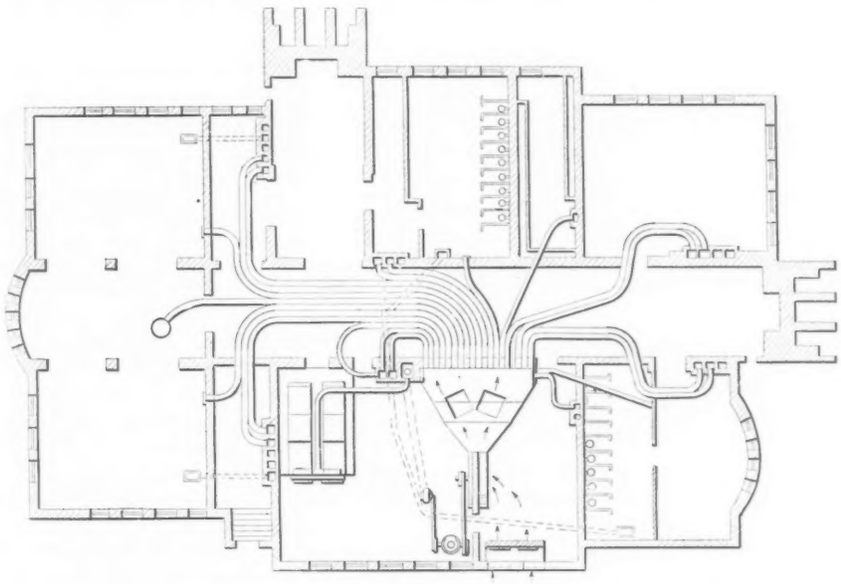


FIG. 4. INDIVIDUAL FLUES FROM A CENTRAL HEATING CHAMBER

Refrigerating Experiences

By John H. Ryan

For a whole winter the writer was around a plant where it was thought that a two-cent stamp would cover all expense incidental to curing the plant of its trouble. The drivers of the delivery wagons commenced to complain of shattered ice which could not be cut up into marketable form, and when cakes of ice were picked over and the broken ones left in the storage room, the manager soon learned of the trouble and reprimanded the engineer for allowing the ice pullers to hustle out their ice and put the cans on the dumps before they were properly tempered up from the brine temperature. The engineer passed the "call" along to the ice harvesters, and they showed him that the ice was split in the cans while still in the tanks. The cracks extended across the 22-inch lengths of the cakes, so that they were split into two thin sheets 5½ inches thick, which is too thin for commercial use.

The Cracks in the Ice

These cracks extended lengthwise of the cakes, and all the other cracked ice the engineer had ever seen had the cracks across the cake, and were always caused by having the spraying or thawing water too hot. In this case the ice pullers had 24 cakes setting out and tempering. They would pull two cakes at a time out of the brine and set them on top of the tank to warm up, and would then put the two cans longest out onto the dump. In this way each man was enabled to pull 192 blocks of 300 pounds each for a day's work. There were two air-operated can hoists and the cranes were operated by hand.

The ice being split in the cans showed the engineer that there was some defect in its manufacture, but the only thing he could think of was that they were carrying the brine temperature too low. The ice storehouse was being filled for summer use, and a brine temperature below 10 degrees Fahrenheit was carried, to get the cakes frosty on the outside, so that they would not stick together when piled one on top of the other.

Ice Should be Frosted

It took them a number of years to find out that the blocks of ice should be frosted on the outside before putting them in permanent storage. At first slats were put between each cake to prevent one cake from touching another, and with this arrangement there was no breakage or trouble in getting the ice out, but the slats made air spaces through the entire body of ice, and any time that the house temperature got above freezing, every cake of ice would "spike" and get so soft that it fell apart in handling. When the company found that they were liable to lose a lot of ice from spiking, they took out all the slats and piled the ice as closely together as possible, figuring that the only part that would spike would be the top tier. This theory was sound, but when they attempted to take the ice out, it was found that there was only one large block of ice instead of the twenty-one thousand 300-pound cakes that had been put in. The loss in breaking out this mass of ice was fully one-third of the whole amount.

After much consideration a common-sense theory was evolved that worked all right in practice. As a cake of ice must be melted on the exterior before it will come out of the can, its whole surface is wet as it is removed. The cake is still below the freezing point and will freeze the water that adheres to the outside of the cake, but generally by the time this happens the cakes are in contact with each other in the ice house and naturally freeze together. If the cakes of ice are allowed to stand separately for an hour in a cold ante-room, they will all freeze dry on the outside, and if then piled close together in the storehouse, every cake will remain loose from its neighbors as long as the storehouse is kept below the freezing point. Next year this plan was tried and the ice came out as good as it went in.

When storing the ice the routine was similar to the lifting and dumping arrangement. No ice was put in the storage

until the men had been pulling for an hour. The first two cakes were then put in, and two more when the next two came from the dumps. This gave every cake an hour in which to dry up before it was put away. To make the ice dry up as fast as possible, the temperature of the brine was kept between 8 and 10 degrees Fahrenheit, and this temperature being lower than ordinary, it appeared to the engineer that it must be the reason for the ice splitting in the cans while they were still in the brine bath.

Cracks Change to Holes

About this time the ice for storage was not put in at the full capacity rate and the brine temperature was allowed to rise to 17 degrees Fahrenheit. In a couple of days the ice quit splitting and the engineer thought he had solved the problem. Such a report was given the manager and in addition a learned discourse on the contraction of ice after it has frozen up solid. Things ran along nicely for a few days until the ice pullers ran into holes, which instead of being the usual shallow V-shaped cups in the top center of each cake, were found to be deep in proportion to their area. A hole that looked not over 2 inches deep was found to be over 2 feet deep. Some cakes showed water in the center of the core with the top of the block frozen over.

The holes closed so slowly that the engineer was forced to pull down the brine temperature. Watching the ice closely, he noticed that the top of the cake closed up first. He was looking at a cake in the tank when it split into two sheets and at the instant of splitting some water was squirted up through the crack.

The Home Office Consulted

The engineer had to admit to the manager that it was beyond him, so the manager wrote to our home office describing his troubles. They replied that it was a simple case of poor circulation of the brine, and went on to explain that when the liquid ammonia was fed to the top of the freezing coils, it would make the brine colder at the top; this would freeze the water in the top of the cans first, and as water expands while freezing, something had to "let go" to give the confined water room. They advised them to tighten up the agitator belts and to make sure that the propeller blades were all on the wheel, as a stick or other obstruction frequently breaks off a blade or twists off the shaft. They concluded with the statement that properly circulated brine of a uniform temperature throughout will freeze the water evenly in the cans, and the taper of the cans will insure the top being the last to close. To this the ice-factory manager replied that the agitator wheels were all running at their proper speed and the brine could be noticed in agitation in front of each propeller.

A Case of Poor Circulation

It was now my turn, and I was sent down to the plant to try and locate the trouble. The engineer always took the temperature of the brine in a vacant can space right in front of the propeller discharge. The first thing I did was to take the temperature of the brine at every 10 feet in the length of the tank. Where the ice was frozen solid in the cans the temperature was very low, and where the cans were freshly filled the brine was quite warm. There was a difference of 12 degrees Fahrenheit between the coldest and warmest parts of the tank, which showed conclusively that the brine was not being properly circulated. The brine could be seen in motion in front of the agitators, and this showed that the trouble was in the bulkheads that guide the brine from one side of the tank to the other. If both bulkheads and agitators were in proper shape, there would not be more than a degree difference in temperature all over the tank.

The agitators were on the same end of the tank as the suction and expansion headers. The suction header was boxed in, and when we removed the planks, there was found a solid mass of ice inclosing the suction pipes. This ice had to be melted off before we could get a look at the agitator bulkheads. It wasn't practical to get hot ammonia gas to melt off the ice, and steam or water could not be used because either would weaken the brine. Salt would be too slow, so we used compressed air in an atomizer made from a tee and a long-threaded nipple. The end of the suction pipe of this atomizer was held over the fire of a portable forge and the hot smoke and gas were blown on the ice, which was melted in a short time. While we were doing this the harvesting of ice was stopped, and the ice-room doors were kept shut because ice will absorb odors quicker than butter will take up the smell of onions. When the ice was melted enough for us to see the agitator casing and bulkhead, we found that the sheet-iron partition, through which the agitator discharged, was rusted out, letting the brine back to the suction side of the propeller, and very little of it was sent around the cans. The partition was beyond repair and the brine had to be taken out of the tank to put in a new one. The harvesting of ice was stopped for two days to let all the cans freeze up solid, because the brine would fall as soon as any of the cans were lifted out and the cups would not close up. The cans were then set on top of the tank and half of them were set bottom up to keep the dust out of them. The other half were set open-end up, and the brine was pumped out of the tank into these cans. The mud in the bottom of the tank was stirred up with a hose and the most of it pumped out.

White Lead and Oil to Prevent Corrosion

There was a very heavy rust scale at the water line of the tank. The most of this was scraped off, and the sides were painted with a mixture of white lead, boiled oil and machine oil, the idea being to give them a coating that would not dry hard. The mineral oil would soak through the rust and prevent any further corrosion of the metal. It made a sticky mess, but the brine did not circulate fast enough to wash it off and the cans never came in contact with the sides to rub it off.

As the bottom of the tank did not appear to be so badly rusted, it was decided to leave it alone, because it is a most disagreeable job to work between the expansion coils, and they did not want to waste the time it would take to disconnect all the coils and move them out of the way.

Freezing the Brine

When the new partitions were finished and the painting done, the brine was dumped back into the tank and the salty cans were all washed out with fresh water. The brine was found to be 2 inches low when all the cans were filled, and it was brought up to the proper hight by running in fresh water. After the fresh water was added, the salinometer showed that the brine would freeze at 13 degrees Fahrenheit, so it was decided to go ahead and freeze up the tank while waiting for salt to come by freight.

It worried the engineer to see the ice pullers standing around, so he decided to pull the temperature as low as possible and freeze the ice up quickly. He knew it would freeze the brine, but he intended to shut off the expansion before the water was all frozen in the cans and allow the temperature to come up to 14 degrees Fahrenheit, so that the salt ice would melt off the coils by the time the ice in the cans was frozen solid. The tank was not watched closely enough, and the brine froze solid between the coils and the cans. The top of the coils, being the coldest, absorbed the heat from the top of the water in the cans and caused it to freeze first. When the engineer came to see if the ice was fit to pull, he found that the whole tankful of ice was split as badly as any they had ever had. He hurried to the office and told the manager that the rusted-out partition had nothing to do with the split ice, for they had 700 split cakes in the tank to prove it. The manager had excellent command of his mother tongue and I can't remember anything he didn't say to me. When he got through, I turned to the engineer and asked him at what temperature I had told him the weak brine would freeze. He replied 13 degrees Fahrenheit. Then I showed the manager the log book in which were re-

corded temperatures as low as 7 degrees Fahrenheit.

Wages versus Repairs

I went over the subject with him again and showed him that there could be no circulation when the brine was frozen around the cans, and, of course, the brine ice would be colder at the top. He threatened to discharge the engineer for the $200 they would lose on the split ice, but I told him that it always costs just so much to run an ice plant, and he would find no difference in his bank balance, whether he paid the larger proportion for repairs and interesting experiences and the lesser amount for wages, or reversed the proportions. Usually the better-paid help will give more satisfactory operation, but they can always find more things to object to and want to spend more money for economies than will the man who has nothing but a healthy muscle to worry along with.

I also suggested that when the brine was strengthened they would have peace of mind for a while, as they had been through all the causes of split ice. Their engineer had a lot of good experience at their expense, and if they added their loss to the value of his services, they would find him too valuable an asset to cast off.

Operating Injectors

By W. H. Wakeman

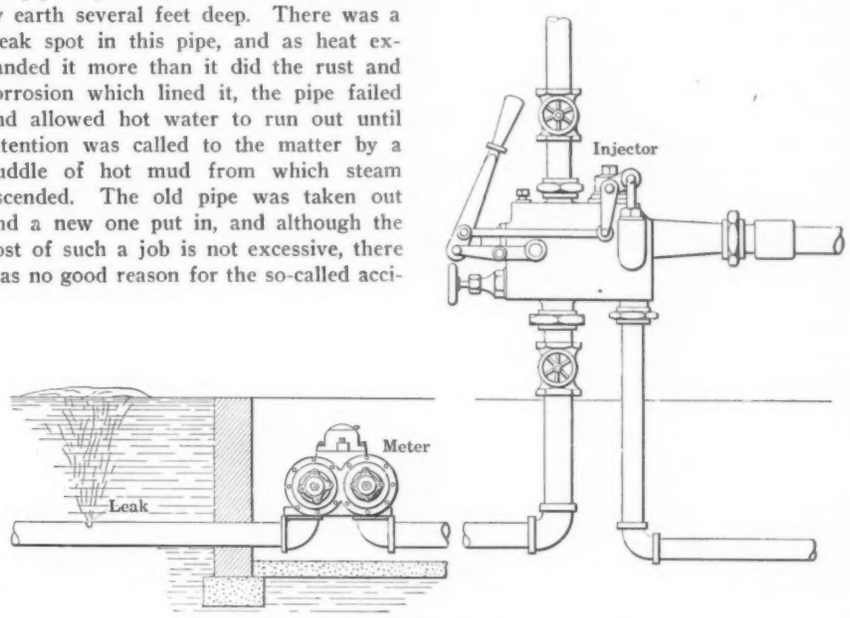
The average visitor to an engine room cannot understand the object in using a barrel or a tank to receive water from a street main, and then taking it out by means of an injector and feeding it into a battery of boilers. This is not surprising, but when a visiting engineer cannot see the advantage of the plan it would seem that there is still a chance for the diffusion of useful knowledge among the craft. The writer has two injectors that take water out of a tank, and one that is fed directly from the street main, thus affording an excellent opportunity to observe the difference in operation. Where a tank is used, the presence of sediment from the reservoir or any other foreign matter is detected before it is sent into the boilers, and by installing a small injector this muddy water can be discharged into the sewer until the supply becomes clear again. This is a much better plan than to find it baked on the shell and tubes in the form of scale.

An injector is more reliable when taking water from a tank than when supplied directly from the street main, for if faucets in other parts of the building are opened suddenly, the reduction of water pressure causes the injector to "kick," which does not happen when taking water from a tank. The latter plan is also convenient for use in dissolving and feeding a compound for removing scale.

When a new assistant engineer or a fireman who is not familiar with the machinery attempts to start either of these injectors, he generally fails to deliver water into the boilers. If steam blows back into the tank he discovers it at once and finds a remedy, but if he fails to properly start the direct-connected injector he does not notice the fault, but goes away and attends to other duties until hot water coming to the cold-water faucets informs him that steam is blowing back into the water-supply pipe, instead of sending water into the boilers.

In a certain plant the fireman attempted to start a direct-connected injector, but for some reason that was not made plain, steam was allowed to fill the water pipes and was forced into them until the cold-water meter was thoroughly heated, also the pipe beyond it, where it was covered by earth several feet deep. There was a weak spot in this pipe, and as heat expanded it more than it did the rust and corrosion which lined it, the pipe failed and allowed hot water to run out until attention was called to the matter by a puddle of hot mud from which steam ascended. The old pipe was taken out and a new one put in, and although the cost of such a job is not excessive, there was no good reason for the so-called accident. In order to guard against such carelessness in the future, a swing check-valve ought to be installed in the supply pipe, to prevent steam from heating the water, but if an unsuccessful attempt is made to start an injector that is connected in this way, and the fireman does not have common sense enough to know whether it is delivering water or not, the only remedy seems to be for him to wait until he must have water in his boilers, when search will be made for the cause of trouble. Another evidence of ignorance along this line is presented when such a discovery is made, and although the injector and all pipes near it are as hot as steam can make them, the fireman attempts to start the boiler feeder without running water through it to the sewer until the injector is cold enough to condense the steam that is delivered to it.

One day the writer was taking water out of the tank previously mentioned and sending it to the boilers, when suddenly the injector "kicked" and apparently the water commenced to boil, although there was no evidence of heat in it. As the injectors were in perfect order and the water supply was not interrupted, I shut the steam valve and began to think over the situation, endeavoring to recall what had been done that day that could possibly cause the failure. Remembering that steam was raised that morning in one of the boilers which had been laid off for several days, the cause of trouble was no longer a mystery. The air that was in this boiler above the water line was discharged into the main header, and when some of it came to the injector the supply of water to the boilers suddenly ceased, as an ordinary injector cannot be operated with air (even if it is hot), and when the air was blown into the tank it caused violent agitation of the water, or in other words it appeared to boil without much heat. When the air was removed from the steam pipe, there was no more trouble from this source.



INJECTOR DIRECT-CONNECTED TO CITY MAIN

There is one point in favor of connecting an injector directly to the water pipe, as in that case it will deliver more water to the boilers than when drawing from a tank. On this account it is a good idea to use another valve or two, also a few feet more of pipe and thus be able to take water direct or draw it from a tank at pleasure.

For filling cracks between commutator bars, a stiff putty made of the white of an egg and air-slacked lime is a better filling than shellac, which dries on the surface, leaving the lower portion damp.

Save the studs. The nuts of hand-hole plates, which have become burnt on, can be easily split off with a hammer and cold-chisel, if a short piece of heavy shafting is propped under the nut.

The Specific Heat of Superheated Steam

Doctors Knoblauch and Jakob Reply to Prof. Reeve's Criticism; Prof. Heck on Reeve's Views of Terminology and Nature of Entropy

By Doctors Knoblauch and Jakob

In the issue of POWER AND THE ENGINEER for February 25, 1908, Prof. Sidney A. Reeve criticized our paper on the determination of the specific heat of superheated steam, published in the *Zeitschrift des Vereines deutscher Ingenieure*, in a manner which cannot be let passed without a reply. Professor Reeve erroneously supposes that we had assumed in calculating the final results the specific heat C_p to be constant from the point of saturation up to the region observed, and that we simply had to find the law in accordance with which C_p varies. He is doubtful about our results and recomputes them on a different basis.

To this objection we reply that Professor Reeve has misunderstood our method of computation, which is very simple and not open to objections, and that his computations are evidently erroneous in principle. The fundamental formula on which we base the determination of the "true specific heat" is the following:

$$C_p = \frac{W - V}{g\,(t_2 - t_1)}, \qquad (1)$$

in which

W = The heat taken in from outside,
V = The heat lost by radiation and convection,
g = The weight of the steam,
t_1 = The temperature of the superheated steam when entering the calorimeter.
t_2 = The temperature on leaving it,
C_p = The true specific heat of steam at the temperature $(t_1 + t_2) \div 2$.

It is hardly necessary to explain that it is allowable to assume that the quantity C_p varies according to some linear law within the small range of $t_2 - t_1$, which on the average amounts to but 40 degrees Centigrade; the same assumption is made by Professor Reeve in his recomputations and is certainly justifiable. Professor Reeve is entirely mistaken if he thinks that we had taken C_p to be constant from the saturation point up to the temperature observed; if he draws that conclusion from our paper, he has misunderstood our method of calculation altogether. It would appear that his misapprehension was caused by the following correction made in our paper, the real meaning of which was not clear to him:

Instead of from the more correct formula

$$\left.\begin{aligned}\lambda_2 - \lambda_1 = {} & 0\,305\,(t_{s2} - t_{s1}) + \\ & C_{ps}(t_{s1} - t_{s2}) + \int_{t_1}^{t_2} C_p\,dt,\end{aligned}\right\} \qquad (2)$$

where C_{ps} denotes the specific heat at the temperature of saturation, we deduced the value of C_p from the equation

$$\left.\begin{aligned}\lambda_2 - \lambda_1 = {} & 0.305\,(t_{s2} - t_{s1}) + \\ & C_p\,(t_{s1} - t_{s2}) + \int_{t_1}^{t_2} C_p\,dt.\end{aligned}\right\} \qquad (3)$$

While Professor Reeve sees a gross mistake herein, in reality it is an approximative calculation of a correction. For the only difference between the two equations is the small quantity $(C_p - C_{ps})(t_{s1} - t_{s2})$, which practically has no influence on the final result.

If equation (2) is used to find the value of C_p instead of equation (3) the following is obtained:

$$\left.\begin{aligned}C_p = {} & \frac{W - V}{g\,(t_2 - t_1)} - \\ & (C_{ps} - 0.305)\,\frac{t_{s1} - t_{s2}}{t_2 - t_1},\end{aligned}\right\} \qquad (4)$$

instead of the equation (5) used by us,

$$C_p = \frac{W - V + 0.305\,g\,(t_{s1} - t_{s2})}{g\,[(t_2 - t_1) + (t_{s1} - t_{s2})]}. \qquad (5)$$

The difference of the values computed according to (4) or (5) does not exceed 0.4 per cent. in any case, as indicated by the following examples, for which the correction would become extremely high;

No. 1, 0.478 instead of 0.478.
No. 2, 0.470 instead of 0.470.
No. 6, 0.487 instead of 0.486.
No. 12, 0.489 instead of 0.491.
No. 18, 0.489 instead of 0.490.
No. 24, 0.497 instead of 0.498.

On this occasion we are glad to express our thanks to Prof. Robert H. Smith, of Streatham, who some time ago sent us a letter to draw our attention to the small correction which could be applied in our computation; he fully recognized, though, that we were dealing with an extremely small correction which could be neglected altogether within the accuracy of our experiments.

As to the remark of Professor Reeve that in our mode of computing C_p, compared with that of Professor Lorenz, there is introduced "another and a larger source of error," we wish to say that the method of evaluating the results is identical in both researches.

In consequence of his erroneous supposition that we had assumed the specific heat C_p to be constant from the point of saturation up to the region observed, Professor Reeve has recomputed the values of C_p from our data. In doing so he comes to variations of C_p which are so improbable that he might well have doubted whether or not his calculations were wrong.

Unfortunately he gives no indications about his method of computation, but we suppose that they are based on the erroneous supposition that not all the heat corresponding to the electrical energy introduced was employed for increasing the temperature of the steam, but that part of it was employed to overcome the resistances of the flow of the steam through the calorimeter.

If p_1 and p_2 are the pressures of the steam before and after passing through the calorimeter, and if the velocity of the steam before and after passing through the calorimeter is the same, as it was with very close approximation in our experiments, the resistance work is

$$\int_{p_2}^{p_1} v\,dp.$$

Then our equation (1),

$$C_p = \frac{W - V}{g\,(t_2 - t_1)},$$

must be written

$$C_p = \frac{\frac{W - V}{g} - A\int_{p_2}^{p_1} v\,dp}{t_2 - t_1}, \qquad (6)$$

A equalling $\frac{1}{427}$,

in accepting the above-named erroneous supposition. Approximating the integral from $v\,(p_1 - p_2)$, when v = the specific volume of the superheated steam at the pressure $\frac{1}{2}\,(p_1 + p_2)$ and the temperature $\frac{1}{2}\,(t_1 + t_2)$, the formula becomes

$$C_p = \frac{\frac{W - V}{g} = A\,v\,(p_1 - p_2)}{t_2 - t_1}.$$

The value of v may be calculated by the equation

$$v = \frac{R\,T}{p},$$

where $R = 47$, if the pressure be measured in kilograms per square meter.

T on the absolute temperature scale and v in cubic meters per kilogram. Calculating in this manner we get the values in column 3 of the accompanying table.

No.	Recomputed by Reeve.	Calculated by Equation (6).	Knoblauch and Jakob.
1	0.414	0.412	0.478
2	0.402	0.400	0.470
3	0.463	0.463	0.474
4	0.430	0.428	0.474
5	0.449	0.439	0.476
6	0.427	0.420	0.486
7	0.450	0.450	0.494
8	0.494	0.492	0.502
9	0.472	0.471	0.490
10	0.479	0.478	0.487
11	0.470	0.469	0.485
12	0.414	0.428	0.491
13	0.550	0.553	0.490
14	0.492	0.491	0.500
15	0.514	0.513	0.531
16	0.500	0.499	0.502
17	0.476	0.474	0.492
18	0.472	0.470	0.490
19	0.490	0.488	0.502
20	0.554	0.550	0.557
21	0.483	0.483	0.500
22	0.474	0.472	0.490
23	0.480	0.478	0.488
24	0.491	0.490	0.498
25	0.488	0.487	0.501
26	0.492	0.493	0.504
27	0.499	0.499	0.509

With the exception of test numbers 5 and 12, the figures of Professor Reeve and those obtained from formula (6) agree so nearly that our supposition concerning the method employed by Professor Reeve is amply justified. But there can be no doubt that this method is wrong. Evidently the work of the frictional resistances is immediately transformed into heat, and the internal energy is, therefore, augmented by the same quantity which had been taken from it to overcome the resistance work. The same reasoning can be deduced by discussing the thermodynamic equations for the movement of gases and vapors.*

For the reasons given we cannot but protest strongly against Professor Reeve's depreciating criticism of our tests, the results of which we claim to be correct.

By Prof. R. C. H. Heck

The writer read with interest Professor Reeve's remarks on thermodynamics in the June 2 number, as provoked by his own discussion of throttling in the preceding number.

It must be acknowledged that the subject under discussion has been approached from different points of view. The original article by Professor Reeve was a presumably practical summary of the results, to date, of experiments upon the specific heat of superheated steam. The writer was at the time especially interested in that item of thermal physics; and when, by a so-called "parallel" method of correcting for pressure drop, the plot of the experiments of Knoblauch and Jakob was made to look like a badly dislocated constellation, it appeared that the matter called for inquiry. There was the stronger reason for this because no criticism of experimental method was involved, but only a little question of routine thermodynamics.

A request for a description of the manner of computation elicited the entropy-temperature diagram given as Fig. 10 in the writer's paper in the May 26 number, and here reproduced as Fig. 1. Consideration of this diagram, in connection with the numerical results published February 25, made it evident that the whole area under the curve $A\,B$, or its equivalent $A\,S\,T\,B$, was being charged against the heat received (from the electric current). First, last and all the time, the writer has insisted, and must insist, that this is incorrect. It is not a "parallel method;" there is nothing in the generally accepted principles of thermodynamics that will justify it; and, further, these

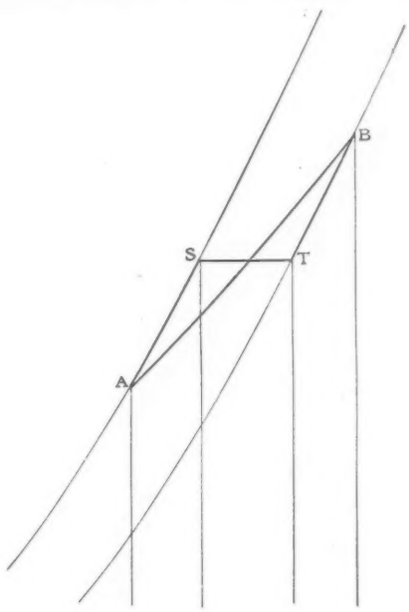


FIG. 1

principles are entirely adequate to the situation, so that there is no need to wander off into a digging up of the foundations of the fundamentals—that is another story altogether.

The "simple mathematical definition" of entropy is

$$d\,N = \frac{d\,Q}{T}, \qquad (1)$$

with the strongest kind of emphasis on the equality sign; it is the only definition upon which a diagram or equivalent useful mathematical expressions can be based. To be compelled to write

$$d\,N > \frac{d\,Q}{T} \qquad (2)$$

is a confession that the entropy-temperature method fails adequately to represent the physical phenomenon under consideration. In the case of wire-drawing there is no real need for making any such acknowledgment of failure.

The standard textbooks undeniably (and properly) devote most of their attention to the so-called reversible processes, in which the symbol $d\,Q$ in the equation

$$d\,N = \frac{d\,Q}{T}$$

stands for heat received from without, from some source external to the working medium. When we come to the complex operation of wire-drawing, where heat already in the expansive substance is transformed first into mechanical energy and then reconverted to heat, we cannot restrict $d\,Q$ to the meaning just given. But by simply broadening the definition of $d\,Q$, and making it stand for *energy which enters the medium in the thermal form*, whether from without or from another internal state, we adapt equation (1) to all the demands that can be made upon it in technical thermodynamics.

The fact that, with $d\,Q$ restricted in meaning to *heat received from without*, the relation written as formula (2) sometimes becomes unavoidable has been met by the statement that the irreversible processes (typified by wire-drawing) cannot be represented by the entropy-temperature diagram. Under the broader definition of $d\,Q$, which lets it stand also for *energy already in the substance in some other form and yet in a sense re-entering it as heat through a conversion process*, this class of operations can be definitely represented. In reality, however, the difficulty is only moved up one step; the diagram now ceases to have a single meaning—what we may call an automatic meaning—and there must be an intelligent analysis, from external information, in order that a distinction may be drawn between heat from without and heat of re-conversion.

Professor Reeve says that we only assume that wire-drawing occurs in the experiments of Knoblauch and Jakob. Excluding the purely thermal action of cooling at constant volume, there are, in the ultimate analysis, only two ways in which a body of gas can pass from a quiescent state at a higher pressure to a similar state at a lower pressure. One is by restrained expansion, through a comparatively slow increase in the confined volume; this is the essential action in a piston engine, and involves the performance of external work upon the moving surface. The other is by throttling or wire-drawing; here the expansive force acts either against the inertia of the mass of the substance or against the frictional resistance of a narrow channel, and the total energy of the substance (of all kinds) remains constant throughout the operation. Of course, we bar radiation and conduction, and also the abstraction of mechanical energy as in a turbine, under the definition just given, and require that all the transformed energy shall

*See Zeuner, *Technische Thermodynamik*, Vol. I, p. 218-225, 1900, or *Encyklopädie der Mathematischen Wissenschaften*, Vol. V, (1), p. 290; also, München, *Laboratorium für technische Physik der Rgl. technischen Hochschule.*

finally return to the thermal state. Now in our particular case, having pressure drop, and certainly not having restrained expansion, how is it possible even to imagine that throttling does not occur?

The writer must express regret if he has inadvertently borrowed anything from Professor Reeve's book; never having had an opportunity to examine that book, he cannot tell how much credit ought to be given.

Doctor Davis' Method

Turning now from the lamentable state of the science of thermodynamics to something that is really of constructive value, the writer would express his cordial appreciation of the contribution made to the discussion by Doctor Davis. His general scheme is, in its simplicity and directness, decidedly preferable to a rather complicated deduction which is, after all, only a rough approximation. Whether we can, however, accept quantitatively the single-relation curve which he gives remains to be seen.

From the data that have been published the writer cannot justify the assumption that the ratio $\frac{\Delta t}{\Delta p}$ is a function of temperature alone. Griessmann's results are probably the best of these data. The original publication was in *Zeitschrift des Vereines deutscher Ingenieure*, 1903, page 1852; and a diagram transformed to English measures by the writer and published in Power for May, 1905, is here reproduced as Fig. 2. The apparatus was essentially the same as a throttling calorimeter, with a porous plug instead of an orifice in a plate. The limiting curve $S\,S$ is the line of saturation according to the coördinates used, and the numbered curves show how the temperature of the throttled steam fell with the pressure—this pressure existing on the low side of the plug. Curve 1 shows wire-drawing which begins with dry steam at about 43 pounds absolute, curve 11 begins at 142 pounds,

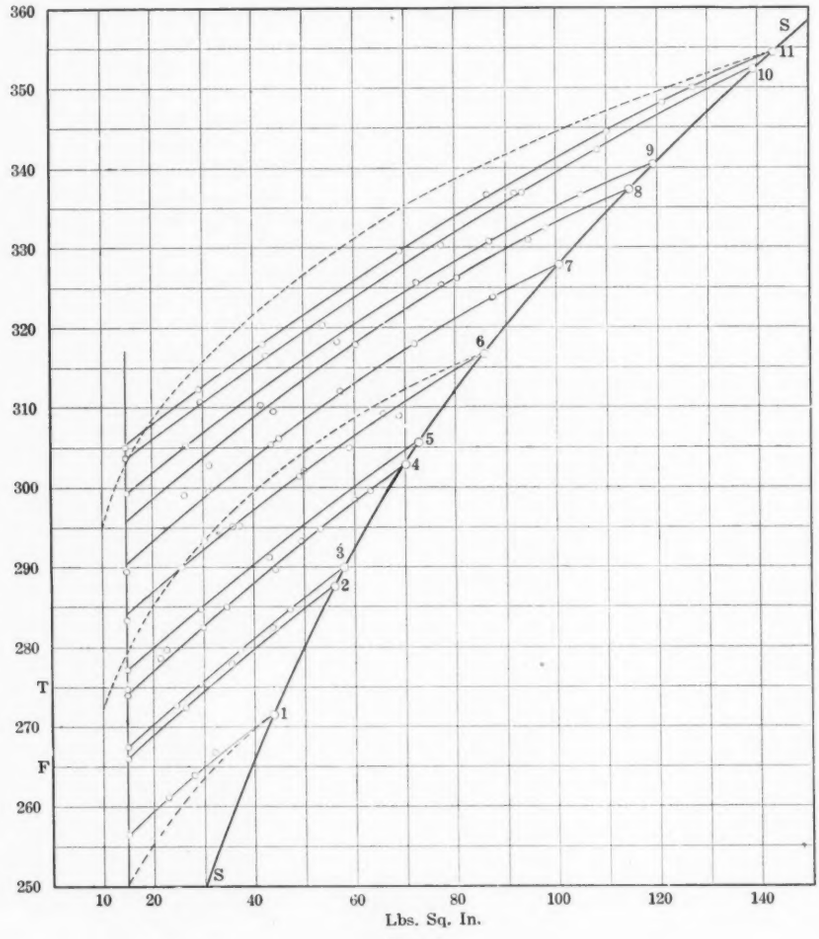


FIG. 2

and so on. From the original diagram, the writer gets the following results:

A tangent to curve 11 near its lower end, where the pressure is about 1.5 kilograms and the temperature 155 degrees Centigrade, has the slant corresponding to a value 3.9 for the ratio $\frac{\Delta t}{\Delta p}$. Running to the right along a line of constant temperature, and drawing a tangent to curve 7, the value 3.3 is obtained. Dropping down at a constant pressure to curve 1, the ratio for this curve at 1.5 kilograms is found to be 4.7. The primary determining condition for these curves is the original pressure (and temperature) on the line $S\,S$. Considering how much greater is the range between curves 11 and 1 than between 11 and 7, we see that the rate of change of $\frac{\Delta t}{\Delta p}$ is really less with pressure than with temperature.

The scheme of using curves of throttling in correcting for pressure drop has suggested itself to the writer also, but these were to be curves derived by computation, instead of being found by direct experiment — an advantage lying in the fact that the range of conditions which can be covered is so much wider. As a first approximation, curves already in existence can be used, even if not based upon quite correct values of C_p. What first led the writer to doubt the general applicability of Doctor Davis' curve for $\frac{\Delta t}{\Delta p}$ is the wide discrepancy in results found by what should truly be parallel methods.

A concrete example will probably clarify the matter. Test No. 2 of Knoblauch and Jakob has, according to Davis, a correction of 0.35 degree in a range of 45.5 degrees Centigrade, equivalent to 0.77 per cent. The confessedly approximate method of Knoblauch and Jakob, as applied to the same data by the writer (on page 825), gives 0.69 B.t.u. in 39.1 B.t.u., or 1.76 per cent. Absolutely, in the immediate connection, the difference of 1 per cent. is not a great matter; but from the point of view of the correction itself, the difference is enormous.

Now let us see what can be got from curves of constant heat that have been published. One good entropy diagram for steam, in metric-Centigrade units, but based on $C_p = 0.48$, comes with Stodola's "Steam Turbines." Scaling from this diagram correlative values of Δt and Δp at the condition $p = 2$ kilograms and $t = 188$ degrees Centigrade, which are average values in the example under consideration (test No. 2), the writer gets a ratio of about 6.1, as compared with 2.5 given by Davis for the same temperature. A similar operation on the entropy diagram by Professor Greene, in the *Proceedings* of the American Society of Mechanical Engineers for June, 1907, page 1704 (based on the work of Knoblauch and Jakob), gives 0.57 degree Fahrenheit per pound of pressure change, as against 0.32 degree from Davis' curve.

To sum up the numerical values for this particular case, we have:

	Per cent.
Correction by Davis' method.....	0.77
By Knoblauch and Jakob's method	1.76
By constant-heat curve for $C_p =$ 0.48, Davis' result times 2.4, or	1.85
By curve on Greene's diagram, Davis' result times 1.8, or.....	1.38

Table for Superheated Steam

There remains to be considered the writer's table for superheated steam, just presented to the American Society of Mechanical Engineers. In applying this, as in the solutions already given, it is

thought best to move the cross-curve $A\,C$, Fig. 9, page 824, up to the mean temperature hight of the operation $A\,B$, instead of taking it at the bottom, at t_1. The data for our example are:

$p_1 = 29.7$ lb. $\quad t_{s1} = 249.8°\ F.$
$p_2 = 27.7$ lb. $\quad t_{s2} = 245.8°$
$t_1 = 329.9°$
$t_2 = 411.6°$ $\quad t_m = 370.8°$

The question is, if steam at 29.7 pounds and 370.8 degrees be throttled to 27.7 pounds, how much will the temperature fall?

The tabular quantity of first importance is the heat h above saturation. Here the initial superheat is 370.9 — 249.8 = 121.0 degrees. A small piece of the table, to one more decimal place than in the paper, takes the form:

$t =$	100	130
$p = 25$	$h = 50.46$	64.81
30	51.00	65.46

t standing here not for degrees on thermometer, but for degrees of superheat.

By double interpolation we get: For 121 degrees of superheat—

$h = 61.08$ B.t.u. at 29.7 lb. abs.,
$h = 60.83$ B.t.u. at 27.7 lb. abs.,

the difference of 0.25 B.t.u. showing the effect of change of C_p with pressure, over this range of heating.

Now 121 degrees of superheat, at 27.7 pounds pressure, would make the temperature t come to 245.8 + 121.0 = 366.8, which is 4 degrees below the initial 370.8 degrees. But the drop of 4 degrees in the saturation temperature t_s sets free $4 \times 0.305 = 1.22$ B.t.u. from the saturation requirement. Add to this the 0.25 B.t.u. from change in C_p with pressure, and we have 1.47 B.t.u. above superheated steam at 366.8 degrees. The table gives 0.479 as the specific heat at this point; then 1.47 B.t.u. will raise the temperature by 3.07 degrees, making it 369.87 degrees; and subtracting this from the original 370.8, we have 0.93 degree as the temperature fall.

On a base of 81.7 degrees this is a correction of 1.14 per cent., and it is probably correct within a narrow margin of error. The writer's guess, page 825, that the error in this case was perhaps one-half of 1 per cent., is well justified.

Some pop safety valves refuse to shut off when the pressure goes down. This puts the engineer in a fix when the valve discharges into a boiler room having a low ceiling, as the heat and dense fog do not permit its being shut off. A chain to close, as well as one to open, such a safety valve is a necessity.

To clean an injector that has been scaled up inside, use a solution of one part muriatic acid and nine to twelve parts of water. Soak until the scale is soft or dissolved.

Brush Sparking

By Jacob Glogau

Sparking at the brushes may be divided into four classes and these designated by names descriptive of the appearance of the spark, as follows: Blue-white, scintillating, greenish-yellow and reddish-yellow.

The small blue-white sparks are not destructive; they are static in origin and produce only a slight heating effect.

Scintillating sparks are not sparks of commutation, but are due to the explosive burning of minute particles of carbon or mixed carbon and dirt. These sparks frequently encircle the entire commutator.

Greenish-yellow sparks are destructive, the distinctive tinge being due chiefly to the burning of disintegrated copper or carbon and copper together, the copper dust predominating.

Reddish-yellow sparks are of the same origin and have the same effect as greenish-yellow sparks. Their color is due chiefly to the burning of disintegrated carbon or carbon and copper together, the carbon predominating.

The causes of the three last-named classes of sparking are as follows:

Scintillating—Rough commutator; high mica strips; one or more low commutator bars; excessive brush-spring tension, or any other condition which grinds off the tips of carbon brushes. With proper mechanical conditions, the ends of the brushes wear down very gradually and smoothly.

Greenish-yellow and Reddish-yellow—Incorrect setting of the brushes; dirty commutator; brushes improperly fitted; loose connections; weak brush-spring tension; an open circuit in the armature winding or connections; excessive overload; unbalanced magnetic field.

Sparking at the Commutator

Sparking at the commutator is a very common trouble and is not serious if it is moderate and of short duration, but when kept up for a long time serious conditions will arise, such as a burned or roughened commutator and excessive heating. One of the principal causes of destructive sparking is the armature being overloaded; the only remedy is to reduce the load at once.

Brushes Not Set Right

The brushes must be placed at the neutral point on the commutator; this can be found by shifting the brushes by means of the rocker arm until the sparking disappears or is reduced to the minimum. The usual position for the brushes is opposite the spaces between the field-magnet pole-pieces, but this is not true of all machines.

A Bad Commutator

Sparking is caused by a commutator which has high or low bars, or is rough, or with mica sticking up and preventing good contact for the brushes. A bad commutator can be detected by placing the finger on the commutator while it is rotating, and feeling for rough spots, or if the brushes make a clattering noise while operating. To remedy this, the commutator should be turned down, then smoothed off with sandpaper and then cleaned with a little gasolene, so as to remove all traces of copper dust. A commutator should have a dull glaze of a brown color. It is also advisable to use a very little vaseline or dynamo oil on the commutator.

Poor Brush Contact

The brushes sometimes only make contact with the commutator at one end, because there may be dust at the other end of the brush or some of the surface of the brush has become coated with a glaze of oil. To obtain good carbon contact, the carbon to be used should be placed in the brush-holder, tension applied to the brush, and a piece of sandpaper put on the surface of the commutator and drawn back and forth under the brush, fitting the brush-contact surface to the curvature of the commutator; then the brush is cleaned with an oily rag and is ready for use.

Short-circuit Armature Coil

In a motor the armature will take excessive current. In the dynamo the armature will require excessive power. The coil will become heated and probably burn out. The machine should be stopped and a new coil substituted for the damaged one.

Short-circuits in Field-magnet Windings

If one of the coils is short-circuited, the faulty coil remains cool and the good coils get overheated; this will cause sparking at the commutator by unbalancing the magnetic field. To test, examine all connections and test them out with battery and voltmeter; if the short-circuit is not accessible it is best to rewind the coil.

An Open-circuited Armature

This produces violent sparking at the commutator. The flashing takes place when the commutator bar connected to the damaged coil is passing from under the brush. If the bars are examined they will be found to be burned, and the mica between them all eaten away. The remedy is to solder the two bars together, or connect them with a jumper.

Sparking is caused sometimes by the vibration of the machine. This may be counteracted in some cases by putting more tension on the brush springs.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

How Much "Bluff" is Justified?

"How far is a man justified in going? Should he seek personal advancement at the possible cost of injury to others?"

These questions appearing in an editorial in the July 7 issue of POWER AND THE ENGINEER may be answered by asking: "How does a man feel when he himself is a victim of some other person's incompetence?"

Generally speaking, unless a man has a very elastic conscience, he will not accept a position in which his actions may result in loss of life or injury to others, unless he feels that he is capable of doing the work at least as well as the average engineer. Life should not be held so cheaply that a man may increase the risks of others in order that he may learn to fulfil the duties of a position which he has accepted, while realizing his own unfitness.

A right-minded man will hesitate to accept a position where his failure to do the right thing may result in serious loss of his employer's property, or that of others. There are ways in which one may become fitted for responsibility before directly assuming it. The progress may be somewhat slower, but it will not be achieved at the expense of someone else.

On the other hand, no employer is entirely fit for his position who places responsibility upon a man without being reasonably sure he is both mentally and physically equipped for assuming it. I say equipped physically as well as mentally because the possession of theoretical knowledge does not, of itself, always fit a man for active work. It is not sufficient that the engineer responsible for the operation of a large plant, or even a small one, should be able to sit at his leisure and write correct answers to theoretical questions. He should possess a trained hand as well as a trained mind, all his senses should be alive, and he should ever be on the alert. Seeing, hearing, feeling, smelling, one might almost add even tasting, are all means by which he learns that things are moving rightly, and he must be quick to recognize the signs which evidence that something is going wrong. His mental process must be sound, and he must be able to act and think at the same time, and to do both with speed.

Briefly, as regards a position of responsibility, he alone is justified in accepting it who is a broad man trained to his work.

GERALD E. FLANAGAN.

Pittsburg, Penn.

In the editorial on "How Much 'Bluff' is Justified?" we have a question of more than ordinary interest. It is a proposition that confronts most of us at one time or another, and one we must needs decide rightly, as our future success often depends on it.

For my part, I am a strong believer in each man's ability to do that which he has made up his mind to do. If a man has an opportunity to take charge of a plant, he can do it, and do it right and successfully, if he makes up his mind to do so. We are prone to be timid about doing things that are new, or assuming responsibilities larger than and different from those formerly handled. I believe in "bluff," but "bluff" of the right kind; for the "bluff" born of ignorance and conceit there is no tolerance.

Self-confidence backed by study and steadfast, earnest work, is the "bluff" that wins. It is nothing more or less than impressing one's ability upon someone else.

The man cited in the second instance of the editorial was most assuredly justified, for, on taking the position, he set out to back up his "bluff" by making good. He broadened his own knowledge and meeting new conditions was able to cope with them, because he was there to make good.

No doubt a power plant is just as safe in the hands of a new man who is making good his "bluff" as it is under the supervision of one more experienced.

The man who is seeking the boiler-inspector's place has my best wishes, because he wants something and is going after it. Why should he not use every legitimate means for acquiring knowledge that will enable him to carry out his work?

Of course, advancement should not be sought at the possible cost of injury to others, but my contention is that with the proper grit, hustle and desire to make good, the new man is just as safe as any that may be had.

F. H. NEELY.

Wilkinsburg, Penn.

A Good Signal System

In the accompanying sketch of a signal circuit, *A* is a single-stroke bell in each of four buildings, wound to a fairly high resistance; *C* is a vibrating bell in the power house wound the same as *A*; *B* is a special double-contact relay having a higher resistance than either bell and adjusted by the spring *S* until it is just a little too weak to attract its armature. To ring the bell in any building and also signal the power house, touch the key *K* for an instant. This short-circuits bell *A* and removes enough resistance from the circuit to allow *B* to operate, thus short-circuiting its own high-resistance coils and opening the shunt-wound vibrating bell *C*. The weight *W* holds the relay closed until re-set, and also acts as an indicator to show which department called. The interrupter on bell *C* makes *A* vibrate in unison with *C*. Any bell may be rung from the power house by tripping the proper relay by hand. This system possesses the disadvantage that it requires four bells in the power house, one for each department. By opening switch *E* the bells stop and thus notify the power-

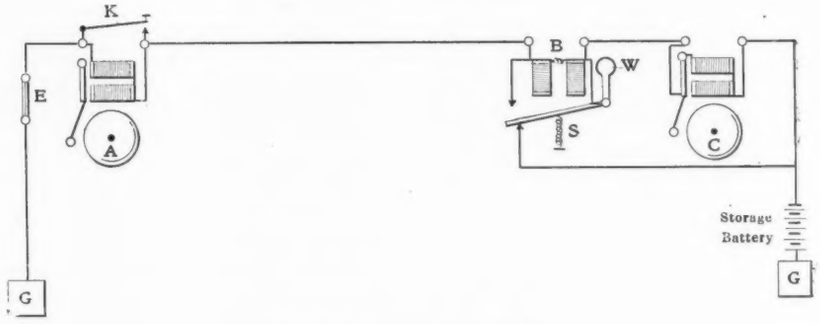


DIAGRAM OF A SIGNAL CIRCUIT

house man to re-set relay *B*, after which *E* must be closed to restore the system ready for the next alarm.

R. H. FENKHAUSEN.

San Francisco, Cal.

Current Consumption of Induction Motors

On page 997 of the June 23 issue, L. A. Thompson asks some questions in regard to the current consumption in his three-phase induction motors, operating air and circulating pumps, which interested me as I have been up against practically the same thing. Had he given a drawing of the piping of the first problem, it would have aided much to its correct solution, but I will try to explain it as I figured it out.

If the air pump is operating on an idle machine, the chances are two to one that the vacuum is two to three inches higher than on a full load. This will mean an atmospheric pressure of one to one and a half pounds more to pump against, which will require some more power.

As near as I can figure from the data given, the diameter of his pump piston must be about 25 inches, which has an area of 490.86 square inches. The difference of vacuum of a little over two inches will equal one pound, or 490.86 foot-pounds of extra work for each foot of travel of the piston. By taking the travel of the piston in feet per minute and figuring the additional power required at the motor, obtained by subtracting the reading of the ammeter at the different periods, which in this case is 35 — 20 = 15, and multiplying this by the voltage and dividing by 746, we have 370 × 15 ÷ 746 = 7.45 horsepower.

The chances are that the end of the discharge pipe is several feet below the level of the pump and during a full load this is full of water, or nearly so, which will overcome some of the air pressure, depending on the distance the discharge is below the pump, thus relieving the pump of some of its work. On an idle machine, this pipe is empty or nearly so. There being no column of water to assist the pump in overcoming the air pressure, all the work is thrown on the pump.

The second case cited, the difference in current consumption at first thought seems impossible under the conditions mentioned, but a few moments' study will make clear the reason. I have experimented with a valve in the discharge pipe of a centrifugal pump which when throttled down will produce the same results and condition as stopped up condenser tubes will. This pump under normal conditions worked against a head of 25 pounds. I found by closing the valve in the discharge pipe until the pressure between the valve and the pump was 40 pounds that considerable less power was required. A centrifugal pump with a clear discharge will expand a certain amount of power throwing the water out, with the discharge closed or partly closed, but the water cannot flow out as fast, hence it will require less power to do the work. The balance of the water will be whirled around in the case of the pump with the runner, whereas, if the discharge were open, it would be thrown out.

The solution to the problem is this: Friction of the water against the case absorbs considerably less power than would be required to force it out against a head. It is a well-known law that to every action there is opposed an equal reaction. What water is not thrown out does not react on the vanes of the runner nearly as heavily as that which is discharged. The power required for a given amount of water with the discharge closed is greater than would be required for a like amount with it open. If you increase the hight of the column of water you are pumping against, until the 40-pound mark is reached with the discharge pipe clear, you will find that considerable more power is required than with a head equal to 25 pounds. This proves again that it is the water whirling around in the pump case with the runner that is responsible for the decrease of power in this problem. It may also be that the change of load on his pumps will change the power factor of the motor some, which will make the reading of the ammeter appear as if the load had changed more than it really had.

CHARLES E. BECKWITH.

Spokane, Wash.

Draft Readings

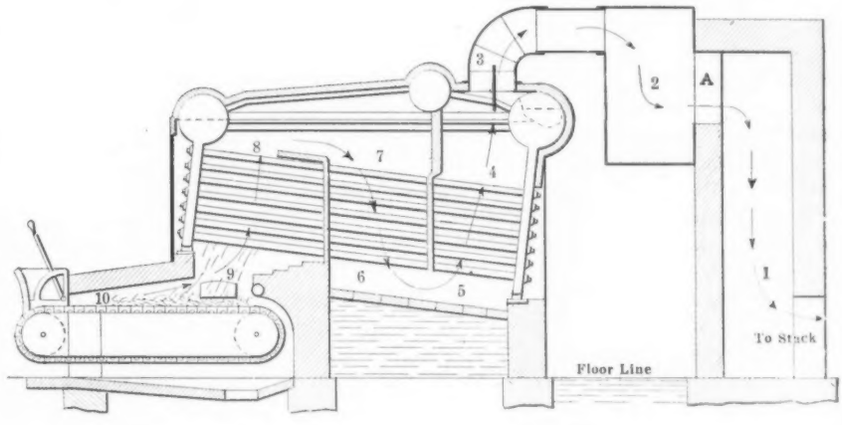
Few engineers realize the amount of information that may be obtained from a boiler setting by means of an accurate draft gage. Here are some of the questions that this instrument will answer:

1. Is the fire of the right thickness for the kind of fuel used?
2. Are boiler tubes or flues free of soot?
3. Are the passes in the boiler correctly proportioned?
4. Is the damper opening sufficiently large?
5. Are there too many bends in the breeching?
6. Are there any restricted passes in the breeching?
7. Is the stack sufficiently high?
8. Is the stack draft correct for the hight of the stack?

On page 174 of the Stirling book may be found correct drafts to correspond with various rates of combustion with the different classes of fuel. The draft in the fire-box should correspond with the values shown in these curves. In a clean boiler the draft will drop approximately 1/10 inch for each turn the gases make from the stack to the grate. If the passes in the boiler are badly proportioned, it will be indicated by a large drop in the draft at the point where the gases are throttled. Quite often damper openings are insufficient; this, too, is indicated by an undue drop in the draft. A right-angle bend in a breeching usually causes a loss of 0.05 in draft.

DRAFT READINGS THROUGHOUT SETTING.

Location.	Draft—Actual Inches of Water.	Draft—Ideal Inches of Water.	Remarks.
1	0.90	0.90	Excessive drop due to restricted pass *A*.
2	0.55	0.70	Normal.
3	0.55	0.70	Normal.
4	0.54	0.68	Excessive drop due to dirty tubes.
5	0.33	0.56	Excessive drop due to soot accumulated in combustion chamber.
6	0.27	0.54	Excessive drop due to dirty tubes.
7	0.12	0.42	Normal.
8	0.10	0.40	Very small drop.
9	0.09	0.27	Normal.
10	0.08	0.25	



A RESTRICTED PASS IN THE BREECHING

Restricted passes in the breeching have the same effect as in the setting: a serious drop in draft. Sometimes, due to various causes, the draft at the stack base is not as high as it should be for such a stack. This, too, may be determined by means of the draft gage.

In the accompanying illustration a case of restricted pass in the breeching is shown. Here a sheet-iron breeching delivers the gases into a brick downtake connecting by means of a tunnel to the stack. The area at the section *A* was too small, causing a drop of from 0.9 inch to 0.55 at this section. This gave a low draft at the damper and caused a smoky fire and an accumulation of soot on the tubes.

In the illustration the numbers show the points at which draft readings were taken, and in the table the tabulated results are presented. In the third column are given a set of readings such as might be expected when the trouble is remedied.

T. A. MARSH.

Chicago, Ill.

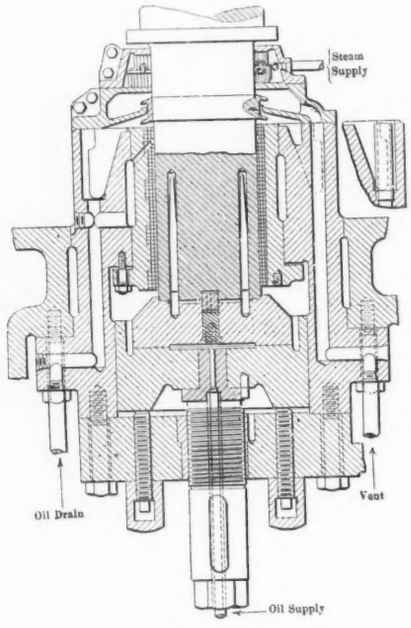
Trouble with Oil Getting into Boilers

Trouble had arisen due to oil getting into the boilers and for a time it had the operating force "guessing" as to what was causing the oil to pass over. On one occasion there was as much as one-half inch of oil in the gage glasses.

The chief engineer felt assured the packing was in good condition, for he had only recently refitted it. The piping system was O. K. also. Upon examining the air vent at the step opening, there were no signs of water passing from this connection, and in fact, by placing a piece of very thin paper over the vent-pipe it was found that there was no suction at all. Asked why this should be so, the chief explained that all the machines in the station had once been operated on water steps, and up to the time that oil was put in there had been no air-vent pipe, but the hole was plugged. After changing over to oil, the plug was removed and a short nipple put in its place. Previous to putting in the plug, while running on water, there was a small amount of water dripping from this hole, and that was why it was plugged.

This made a clear case of what caused the trouble, and the chief was advised to force a gallon of strong lye water into the exhaust base, and also remove the carbon-packing casing and pour lye water into the vent pipe shown in the accompanying sketch. This was done, and in a few seconds a small amount of water was seen coming from the lower end of the vent. Then suddenly the water came in a rush, bringing with it the substance that had stopped up the vent. The lower end of the vent was plugged and more lye water was poured in at the top and allowed to remain in the pipe for some time. Then the plug was removed and water passed from the pipe very freely. The packing was refitted to the shaft and the machine put into service. There was quite a suction at the vent and an occasional drop of water came out. It was impossible at that time to learn whether the oil was still going over to the boilers, for there was oil in the boilers already, as explained.

However, in a day or so no oil was visible in the gage glasses. While the machine was being run on water there was no occasion to have the vent pipe open. The pipe remained plugged for 14 months and the passages had become stopped up with mud and sediment. No trouble was experienced, however, until



OIL STEP-BEARING

on one occasion the packing in the exhaust base was refitted, and in putting the carbon-packing casing together the gasket became torn and a part of it was left out; also, the joints of the casing had not been bolted up as tightly as they should have been; so when the machine was again put in operation, and had a vacuum of 28½ inches in the exhaust base, there was nothing else but for the vacuum to draw the oil of the discharge chamber into the exhaust base, which passed over the tubes down to the hot-well and then to the boilers. This would not have happened had the vent pipe been open so air could have passed up into the discharge chamber, for the vacuum would have had the air to draw out instead of oil. To insure perfect operation the vent pipe must be kept open at all times, and when working properly there will be a slight suction at the end. It is also natural for an occasional drop of water to pass from this pipe. Oil should not come from the vent at any time; if it does, it would be well to learn why the oil is so in the discharge chamber.

The suction is caused by the return oil flowing from the discharge chamber into a drain pipe to the filter. As the oil flows from this practically air-tight chamber (air-tight only for the vent), it is bound to draw in some air.

A small amount of water and vapor should flow continually from the lower carbon-packing casing, usually to the sewer. Never allow a suction or vacuum to be created on this drain line.

SINCLAIR WORTH.

Philadelphia, Pa.

Development and Use of Formula for Indicated Horse-power

On page 993 of the June 23 issue, C. G. Peterson criticizes Mr. Darlington's article in reference to the horse power of a 20x20-inch engine, running at 120 revolutions per minute with 60 pounds mean effective pressure. He states that the horse-power of 169 is incorrect and that it should be 343 horse-power. It seems to me that Mr. Peterson himself must have fallen into an error somewhere, for surely

$$\frac{2 \times 60 \times (20 \div 12) \times 314.16 \times 120}{33{,}000}$$

does not equal 343 as stated. He also says that in the well known formula

$$\frac{PLAN}{33{,}000}$$

the letter N equals the number of revolutions. I have always used N as the number of power strokes per minute, and when used as such it avoids any confusion between double- and single-acting engines. The horse-power found by this formula is not theoretical at all, as Mr. Peterson claims, but is the actual horse-power developed. It is the brake horse-power that is equal to the indicated horse-power multiplied by the mechanical efficiency of the engine.

Another paragraph I would like to call attention to is where Mr. Peterson states there is "no indicator fast enough to take an accurate card at these high speeds" (1000 revolutions per minute). An indicator has recently been developed in which the moving parts have been reduced to a small oscillating mirror which reflects a pencil of light onto a sensitized paper which, upon being developed, produces the card. This instrument is claimed to have overcome almost all the errors of inertia and to be as reliable at the speed spoken of as the standard instrument is on a Corliss engine. I have never used one of these instruments and, therefore, cannot vouch for the accuracy of these statements.

Finally, I wish to ask Mr. Peterson if he is sure his formula

$$\frac{2P \times L \times A \times N \times 4 \times 2}{33{,}000}$$

is correct for a "four-cylinder double-acting two-stroke-cycle engine," or will it show twice the horse-power actually developed?

GEORGE P. PEARCE.

Exeter, N. H.

Calculating the Strength of Riveted Joints

In the July 7 number there is an article by S. F. Jeter on the above subject; also an editorial comment on certain of the points discussed. This article and the accompanying editorial discussion offer me the opportunity to express in public an idea which I have long held, and often expressed to my students and friends, namely, that *no* steam boilers, except heating boilers operated under a gage pressure of 15 pounds, or less, should be constructed with longitudinal lap seams. All boilers intended to carry pressures greater than 15 pounds should be built with butt seams, strapped inside and out, except when such seams are girth seams, or for the attachment of manholes or domes. Further, it is my belief that when a boiler having a longitudinal lap seam explodes through the failure of that seam, the owners of the boiler should be jailed for manslaughter, in case anyone is killed.

There is an objection to the lap joint with an inside strap, when made without a filling piece, as shown by Mr. Jeter,

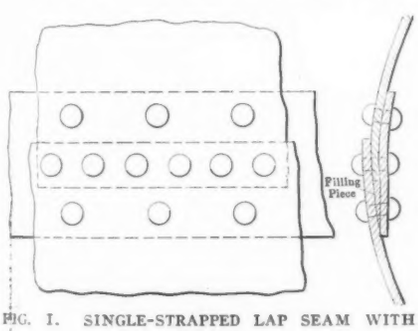


FIG. 1. SINGLE-STRAPPED LAP SEAM WITH FILLING PIECE

which I have never seen mentioned. It is this: The outer row of rivets passing through the outer lap of the plate (the lower row in each of the illustrations) does not take its share of the strain, on account of the elasticity of the strap where it bends over the edge of the inside lap. Consequently, the joint is no stronger with the strap than it would be without it. If, however, a filling piece having the same thickness as the main plate is placed under the strap, as shown in Fig. 1, this condition does not hold. The joint is then as strong as Mr. Jeter's rules would indicate.

When it is necessary to strengthen a lap-seam boiler, in first-class condition, the best way to do the job is to use two straps, one outside and one inside, as shown in Fig. 2. Such a seam is in every respect equal to a butt-strapped seam of the same efficiency, although it is somewhat expensive to make on account of the extra strap.

This joint may fail in a variety of ways. It may tear along the outer row of rivets on either side, in which case the efficiency is $(p - d) \div p$, where p is the pitch of the outer row of rivets, and d is the diameter of the rivet holes. It may crush the rivets B C D E F, although such a method of failure is very unlikely, when the rivets are of the diameters ordinarily used. It may fail by double shearing rivet F, and tearing along the row B E, or, what is more likely in the ordinary case, crushing F and tearing in the row B E as before. Or it may fail by shearing all six rivets in the unit section, in single shear. Such a joint would always be a repair of a double-riveted lap seam, and if the seam were originally properly proportioned, the method of failure would be by tearing the main plate along the outer row of rivets. It would be well, however, to check the other methods of failure by the methods given by Mr. Jeter, to see that there is no error in the matter.

In designing a boiler, or other cylindrical-riveted shell under pressure, it is necessary to know the probable efficiency of the joint, before the thickness of the shell may be determined. It may be shown mathematically that the maximum possible efficiency of a properly designed riveted joint is

$$E = \frac{M + N}{M + N + (T \div C)},$$

where

E = Efficiency of the joint,

M = Number of rivets in single shear in each unit section,

N = Number of rivets in double shear in each unit section,

T = Tensile strength of the plate in rivets, in pounds per square inch.

C = Crushing strength of the plate or rivets, in pounds per square inch.

Mr. Jeter takes 55,000 for the value of T and 95,000 for C, but I think the latter value is quite a little too high, although it has the sanction of some of the boiler-insurance companies. I much prefer to make the value of the ratio $T \div C = 0.72$. The efficiency of joint then becomes equal to the number of rivets per unit section, divided by the number plus 0.72, or expressed as a formula:

$$E = \frac{M + N}{M + N + 0.72}.$$

After having found the efficiency of the riveted joint, the thickness of plate required may be found by means of the well-known rules or formulas dealing with the matter, and then it becomes necessary to find the proper diameter of rivet to use. It may be shown that when the crushing strength of the material is 1.4 times its tensile strength, which is the ratio I have already assumed as proper, and when the shearing strength of a rivet in double shear is 1.75 times that of the same rivet in single shear, which is the value allowed by the British Board of

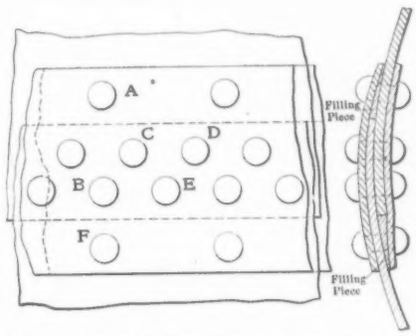


FIG. 2. DOUBLE-STRAPPED LAP SEAM WITH FILLING PIECES

Trade, then the proper rivet diameter may be found by the formula

$$d = 1.8\,t\,\frac{T\,(M + N)}{S\,(M + 1.75\,N)},$$

where

d = Diameter of the rivet hole in inches,

t = Thickness of the plate in inches,

T = Tensile strength of the plate in pounds per square inch,

S = Shearing strength of the rivet material in pounds per square inch,

M = Number of rivets per unit section in single shear,

N = Number of rivets per unit section in double shear.

Having found the proper diameter of rivet, it is next in order to find the proper pitch of the rivets, i.e., the proper distance, center to center, of the rivets in the outer row. To do so, compute the shearing strength of all the rivets in the unit section, divide this by product of the thickness and tensile strength of the plate, and add the diameter of one rivet. Expressed as a formula, this becomes

$$p = 0.7854\,d^2\,\frac{S\,(M + 1.75\,N}{T\,t} + d,$$

where

p = Pitch in inches of the outer row of rivets,

d = Diameter in inches of the rivet holes,

S = Shearing strength of the rivet material,

T = Tensile strength of the plate material, both in pounds per square inch,

t = Thickness of the main plates in inches,

M = Number of rivets per group in single shear,

N = Number of rivets per group in double shear.

The pitch so found may be so great that the joint is not steam-tight. To insure that the joint is steam-tight, the British Board of Trade requires that the pitch shall not exceed

$$C\,t + 1\tfrac{5}{8}$$

inches, where t is the thickness of the plate in inches and C is a constant taken from the following table:

Number of Rivets per Unit Section.	Lap Joints.	Double-strapped Joints.
1	1.31	1.75
2	2.62	3.50
3	3.47	4.63
4	4.14	5.52
5	....	6.00
11	....	12.00

In case the rules for proportioning riveted joints for maximum strength give a pitch greater than that given by the Board of Trade rule, the latter pitch should be taken and the proper diameter of rivet chosen to give the maximum strength with that pitch.

FORREST E. CARDULLO.

Syracuse, N. Y.

Belt Lacings

On page 912 of the June 9 issue, Earl E. Webster asks for information about belt lacing. I have in use four different kinds of lacing which we will place in three classes, i.e., for belts working in dampness, for belts working in a temperature of 120 degrees heat and over, and for belts working in dry places and in normal temperature. Regarding the first, I use mostly rubber belts with rawhide lacing. I have found iron and steel clamps to be absolutely useless for any belt that is wet. The same applies to belt-lacing machines using wire, the principal trouble being where the clamps or prongs pierce the belt, as rot is likely to set in and necessitate cutting out a piece of the belt in a short time.

Regarding the second type of belt, I have several working in a temperature of from 150 to 200 degrees. I have tried lacing with rawhide clamps and also machine spiral-belt lacing, the latter being the best for leather belt, as the rawhide lacing soon dries up and breaks, while clamps burn and tear the belt. A good canvas-woven belt has given me better results than leather in such heat, but it was a case of using rawhide lacing, as the spiral belt lacing has a tendency to unweave one end of the belt and in time pulls out and leaves a very ragged end.

For ordinary running belts I use principally leather, the best lacing for which I find to be the spiral lacing. By sewing on the machine and sinking the lacing in the belt, a perfect joint is obtained, and the belt is able to run on a smaller pulley than would be possible with clamps.

I have several leather belts running at a very high speed which are laced by hand with wire lacing and sunk into the belt with a hammer. When using spiral lacing on these belts, I find the hinged joint wears too fast.

I have also had excellent results with canvas-woven belts in damp places by using metallic lacing. I generally lace them three-quarters of an inch from the joint, and for leather belts, from 10 inches to 24 inches. I have one 20-inch leather belt driving a 120-kilowatt generator. The driving pulley is 104 inches in diameter and operates at 140 revolutions per minute. The driven pulley is 20 inches in diameter. From center to center of the shafts is 12 feet. I think this is rather severe service on such extreme pulleys and short centers of shafts, as the belt must be kept very tight, yet the metallic lacing has been in two years and given no trouble.

GEORGE H. HANDLEY.

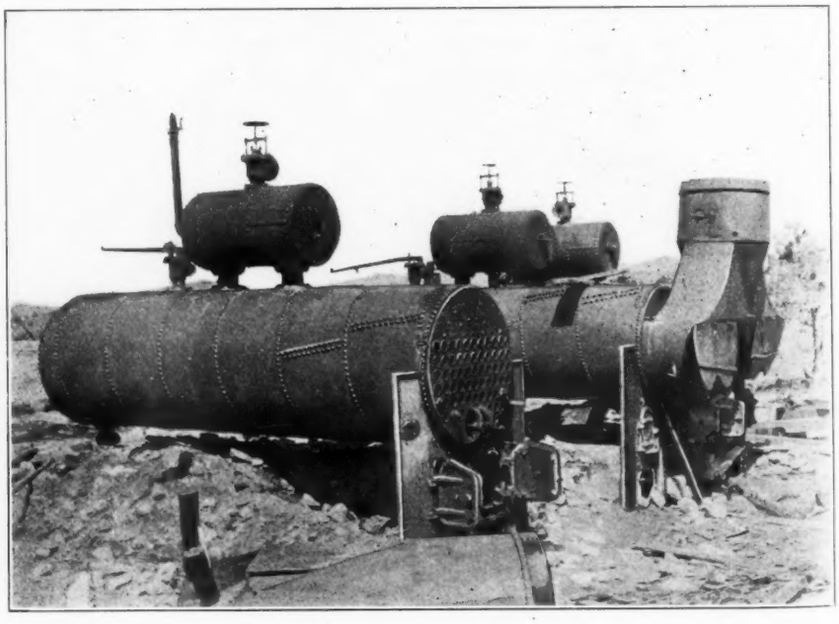
Newburgh, N. Y.

Boilers with Odd Rivet Seams

Herewith is a picture of some boilers that I saw a short time ago. They were a curiosity to me. They are located at an old mine near here and have been abandoned, although they look as though they could give good service for several years yet. It will be noted that they are of the return-tubular type. The curious part is that their girth seams are in the form of a helix, or the same as a spiral-riveted pipe. The name-plates on the boiler fronts indicate that they were made by the Vulcan Iron Works, but do not name the town in which they were made. They were presumably made in Denver, Colo.

AUGUST F. FREY.

McGill, Nev.



SHOWING THE HELICAL RIVET SEAMS.

Who Knows About Burning Soft Coal Screenings?

Has any reader had experience with burning soft-coal screenings, with natural draft, on ordinary stationary grate bars, with the furnace not more than 24 inches from the boiler shell? If so, what percentage of saving was gained over using run-of-mine or anthracite? Was the service given as reliable as when lump coal was used? What effect would burning soft screenings have on stationary bars? Would it not have a tendency to warp them if a very thick fire was used, as very little air could penetrate it unless it was constantly barred up?

An inventor was trying to get a man to install a smoke consumer. It consists of a number of tubes taking air from the ash-pit and allowing it to escape into the furnace at the top of the bridge-wall. His contention or claim is that the air will become heated, and even with a soft-coal fire the amount of black smoke escaping from the stack will be practically *nil*. Have any readers had any experience with such a device, and if so, what was the result of it? I imagine the foregoing questions should be of "burning" interest, in more senses than one.

JAMES E. NOBLE.

Toronto, Ont.

Most Economical Vacuum for Reciprocating Engines

At one time I was very anxious to obtain and retain as nearly a perfect vacuum as practice would permit. During this period, which covered some months, it was my lot to receive many "jolts." The craze overtook me while a watch engineer in a central power station located on the banks of the Pawtucket river; the water was plentiful with no more lift than in marine service; the plant was equipped with two pairs of Harris-Corliss cross-compound 22 and 40 by 48 engines with closed heaters, steam-jacketed cylinders and jet condensers. The pumps were run from the low-pressure crank-pins (we were nearly at sea level), and taking into consideration that at times the engines were carrying all that they could comfortably, with 120 pounds steam pressure, a high vacuum would help out materially; so the conditions and opportunity for me were looked upon as ideal.

The peak of the load was carried on an average of 3½ hours; it was composed of railroad, street-light, alternate, commercial circuit, store and public-building service, and many private houses were lighted by our service also. This was a very prominent place in the eye of the public when trouble developed, but vanished from thought when running smoothly; so we were compelled to act with forethought in any plan, always taking the service into consideration.

There were two sets of men standing a 12-hour watch, changing alternately each week. Each shift was composed of a watch engineer, oiler and one fireman. There were 10 horizontal tubular boilers all in use the first part of the night; it can be seen there was no more help than was required under the most favorable conditions. On Sundays all appliances were thoroughly overhauled and put in the best of condition preparatory for the week to come.

I had made up my mind to get as good vacuum, if not a little better than the other "boys" In this effort I started with all instruments, gages and appliances tested and corrected. Too much stress cannot be placed on this matter, for a man has to depend on these readings for success in such cases. Both watches had previously been in the habit of carrying 24 inches of vacuum, and if no fluctuations showed on the gage, they were satisfied in this respect. The first night of my trick being Saturday and the heaviest, by considerable, from the rest of the week, I was contented by getting 26 inches, and to all appearances everything showed well. I had taken the oiler into my confidence so that both of us were constantly on the lookout for the least sign of distress. The following night, by hard work, 28 inches was obtained, and as the load increased things looked bright for an hour or so, with the exception of the pumps showing signs of distress, but we thought that if the lost motion was taken up on the first opportunity it would improve this defect.

I was about to go into the fire room to see how much relief was felt in that direction when the oiler reported a hot crank-pin. The receiver pressure was changed to equalize the load, when both the low-pressure cylinders began to groan; the hand pumps were worked and the lubricators started faster, but with little or no relief. The other unit began to heat, and at this point the vacuum was allowed to fall off to 26 inches, and in 20 minutes everything was running normally and continued so until a high vacuum was built, when the same troubles would be repeated, including leaks around the condensers, so at intervals I would start for the cellar with a candle in one hand and a ball of putty in the other, seeking where the outside world was trying to enter and destroy my pet hobby. I fought against nature with more or less (mostly less) success for some time, before I came to the conclusion that after passing the point where crowding begins and it is required to maintain a high vacuum (I consider 28 inches high), more is lost in many ways than can be gained. I have found in my varied experiences that 26 inches of vacuum with a temperature of 110 degrees Fahrenheit for discharge has given me the safest and most economical results.

I am not able to explain why a vacuum of 28 inches should prove so annoying any more than I could give definite reasons why a boiler refilled with fresh water should be so much more efficient than one that runs on the same watch for some time, but practice points in many cases to "so far and no farther."

The bringing up of this subject of vacuum reminds me of a rubber mill where I was in charge of the power plant to some extent. There were two 28x40 engines taking water from the Blackstone river for condensing purposes. The load was on par with a rolling mill. Sometimes while breaking rubber we would lose the vacuum, causing a slowing down to recover. This was very annoying, more so to the engineer than to others. It was the means of bringing up vacuum for discussion by those higher up, and in many instances outside information was sought.

Different plants were visited by the superintendent, with the result of a higher-vacuum cure. I was approached on the subject at last, with the information that if a full vacuum was carried at all times it would not be so easy to break. I was somewhat surprised and taken back at such a statement, and said that it was next to impossible to obtain such results, thinking that if I was truthful he would see through my explanation. I told him I had found 26 inches to be the safest and best in many ways, explaining my reasons but not convincing him, for he had seen no crowding nor distress in plants that were carrying 28 inches; and with this feeling he left me.

The rest of the afternoon was spent in thought. This was a good position, and as far as could be seen I was giving satisfaction. At one time previous to this discussion I had called his attention to a false reading on one of those engines. The breaking of a valve-stem allowed the vacuum to draw the disk up to the seat "by-passing" the exhaust to the roof, the gage connections being on the wrong side of the valve. It gave a reading of 28 inches while the engine was on high pressure. This and other evidence were lost sight of through his opinionated obstinacy, and diplomacy had to be used. I was not in favor of "faking," but in this case something had to be done; so after supper I returned and set the pointers ahead, falsifying the readings, and felt justified in so doing, as it hurt no one, gave him satisfaction, and nobody but I was the wiser. I have no doubt many gages reading 28 inches are in the same class, and if a mercury column were to be attached a misrepresentation of a true state of affairs would de disclosed.

W. T. Crowell.

Winsted, Conn.

I submit herewith some facts taken in our plant from a compound engine of approximately 200 horse-power.

With a vacuum of 22½ inches the discharge from the surface condenser was 50 pounds per minute; with a vacuum of 27 inches the discharge was 44 pounds per minute; with a vacuum of 28½ inches the discharge was 40 pounds per minute. If you take this on a basis of 10 hours per day and 365 days per year, you can easily estimate the saving in coal that will be made in that time. In an electric-light power plant it pays to maintain as high a vacuum as it is possible to maintain, varying the pressure, if necessary, to keep the cut-off at the most economical point. By so doing the economy will be maintained at the highest point. Now the temperature of the water in connection with the above results is maintained at 200 degrees Fahrenheit at all times by the following method:

A properly proportioned heater is placed between the engine and condenser and called the main heater. A heater called the auxiliary heater is used to raise the temperature of the water from the main heater by means of exhaust steam from the steam end of the air pump, the pump that returns the condensation from the reheating receiver of the engine to the boiler and the feed pumps. No attempt should be made in a central power plant to follow marine practice in this respect, as usually the condenser lay-out and cut-off control are such that a higher vacuum

would make it harder to control the speed in rough weather, and owing to the absence of heaters in a majority of cases it is necessary to maintain as high a hot-well temperature as possible, as the water is used over and over again, it being very desirable to keep salt water out of the boilers. In reference to the high vacuum, I will say that it tends in a central station to improve the speed range, and in case of light load or no load should the eccentric valve setting be incorrect, the engine is liable to speed up under light load materially, and to be absolutely out of control in case the load should be lost, but the economy will be better than at a lower vacuum.

A. E. WALDEN.

Baltimore, Md.

Cause of a Hot Crank

An engineer had a hot crank not long ago, caused by stopping his engine above center and starting it next morning too quickly. He had no oil cup on the top of the brasses, but used only a centrifugal oiler. He turned on the oil cup on the stationary stand all right, but because the oil couldn't run up hill the pin remained dry, until it came below center, and then he opened the throttle so quickly that the load came on the pin and cut it before the oil could get out to it. Now he always stops with the crank below center, and when he turns on the cup the oil gets a chance to run down and lubricate the pin ready for starting. I think stopping above the center is a bad practice on this account.

DANIEL C. CHITTENDEN.

Brantford, Ont.

Low Water as a Cause of Boiler Explosions

In the May 15 issue of POWER AND THE ENGINEER, page 740, George C. Sweet in an article entitled: "Low Water as a Cause of Boiler Explosions," writes as follows: "It is hardly right to let such an article as that on 'Low Water as a Cause of Boiler Explosions' in the March 17 number go uncorrected."

He probably refers to the article by Mr. E. H. Lane which appears on page 413 of that issue. I agree with him that the article in question needs correcting. Referring to page 631, of the April 21 number, it would seem that G. R. Haight has the same conscientious scruples in regard to this article. I agree with Mr. Haight that 30.112 is rather a surprising value for the heat in one pound of water at 105 pounds absolute pressure; this may have been meant for 301.13, but even this is not the correct value, 302.6 being the number of heat units in one pound of water at the given pressure.

Mr. Haight says that the standard steam tables give the heat in one pound of water at the above pressure as 1182.9 B.t.u., while Mr. Sweet uses 1183 B.t.u. as the correct value; he does not state that he found this in a standard steam table, but I presume that is what he meant to say. If these gentlemen will take the trouble to consult their standard steam tables again they will, I think, find that the heat in one pound of water at 105 pounds absolute pressure is 302.6 B.t.u. The figure they have used is the total heat in one pound of *steam* at this pressure.

The 8300 pounds of water would contain $8300 \times 302.6 = 2{,}511{,}580$ B.t.u. The heat available per pound of water is $302.6 - 180 = 122.6$, giving a total of 8300 times 122.6, or 1,017,580.

To evaporate one pound of water to steam from and at 212 degrees Fahrenheit requires 965.7 B.t.u.; 1,017,580 B.t.u. would, therefore, evaporate 1054 pounds of water, leaving 7246 pounds still in the form of water at a temperature of 212 degrees Fahrenheit.

Mr. Lane used the value corresponding to water at 103 pounds instead of 105 pounds.

Some of our practical engineers seem to delight in finding flaws. This is a good thing, for if an article is incorrect it should be corrected; if, however, one is to correct another's mistakes he should be sure that he himself is right, and not send in solutions, which, like the two corrections mentioned are absolutely wrong in their fundamental reasoning.

EDWARD J. TRIMBEY.

Glen Falls, N. Y.

["To err is human." This is doubtless the reason why Mr. Trimbey refers to the May 12 number as May 15.—EDITORS.]

Good Way to Clean Out a Pipe

A drain pipe was stopped up with dirt and had to be cleaned out. The drain consisted of a 1½-inch iron-pipe line, with a lot of elbows and bends in it. It ran from a sink through floors, walls, etc., which made it extremely hard to get at. I tried to take it apart with a pipe wrench, but the joints were so rusted that I could not start them. I recalled a definition in hydro-mechanics to the effect that "the pressure per unit of area exerted anywhere upon a mass of liquid is transmitted undiminished in all directions, and acts with the same force on all surfaces in a direction at right angles to those surfaces."

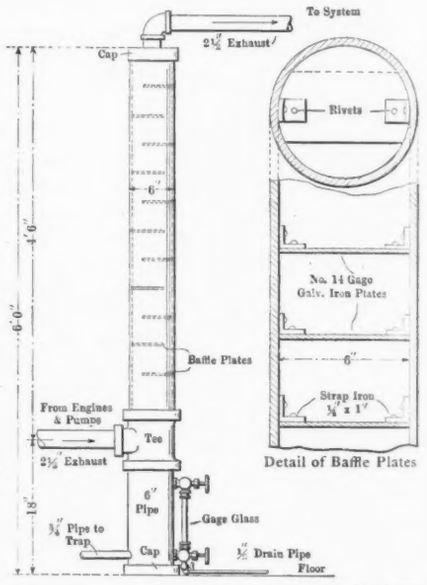
I filled the pipe, above the choked place, with water and made a sort of piston by taking a round stick of wood, about a foot long and a quarter of an inch less in diameter than the inside diameter of the pipe, and wrapped strips of rag around one end, so this end would fit into the pipe snugly. I placed this end of the piston in the pipe, so it would press on top of the water, and struck it on the other end. The water transmitted the blows it received on its surface to the dirt which clogged the pipe and forced it out in about five minutes.

F. E. FICK.

Govans, Md.

Home-made Separator

In response to the inquiry by E. B. Austin, in a recent number, for a home-made oil separator, I herewith submit a sketch of one I found in a plant I had charge of some years ago. It was made by a steam fitter who installed the plant.



EXTERIOR AND INTERIOR VIEWS OF SEPARATOR

and is the best oil separator I ever saw, either factory or home-made. No oil got by into the system that I ever knew of.

As nearly as I can remember the exhaust entered the separator about 18 inches from the bottom. The area of the 6-inch pipe being so much greater than the 2½-inch pipe allows the steam to zig-zag slowly upward in the nature of a slow-moving vapor. If the area of the upright pipe is large enough, the baffle plates are not required. The plates are notched on the sides so that the 1x¼-inch iron upright pieces just come flush with the outer edge, thus making a tight, smooth fit to the pipe. The iron uprights are bolted to the pipe by ¼-inch bolts (not shown in the sketch), thus preventing slamming or rattling.

Ordinarily the trap will keep the base clear, but if the trap should fail to work, the oil and water will show in the gage glass and the ½-inch bleeder can be used until the trap is in working order again.

J. E. BATES.

Spirit Lake, Idaho.

The Glocker-White Turbine Governor

Hollow Balls Containing a Shifting Charge of Mercury Introduce Exactly the Properties Required in Water Wheel Governing

BY W. M. WHITE * AND L. F. MOODY †

Before explaining the principle upon which this governor acts, it is necessary to outline the difficulties connected with the regulation of large water-wheel units. Unlike the steam in the supply pipe of an engine, the water in a penstock is possessed of a large amount of inertia, which with the large capacities and high heads of existing plants this may very easily burst the pipe. Added to this is another action which momentarily reverses the intended effect if the gate is suddenly operated. If the gate is partially closed with a sudden movement, the effect of the effect, the velocity through the enlarged opening being, for the moment, reduced and the speed of the wheel with it.

It is, of course, desirable that a water-wheel be regulated as closely as a steam engine, and it is entirely possible to do this after the water has had time to adapt

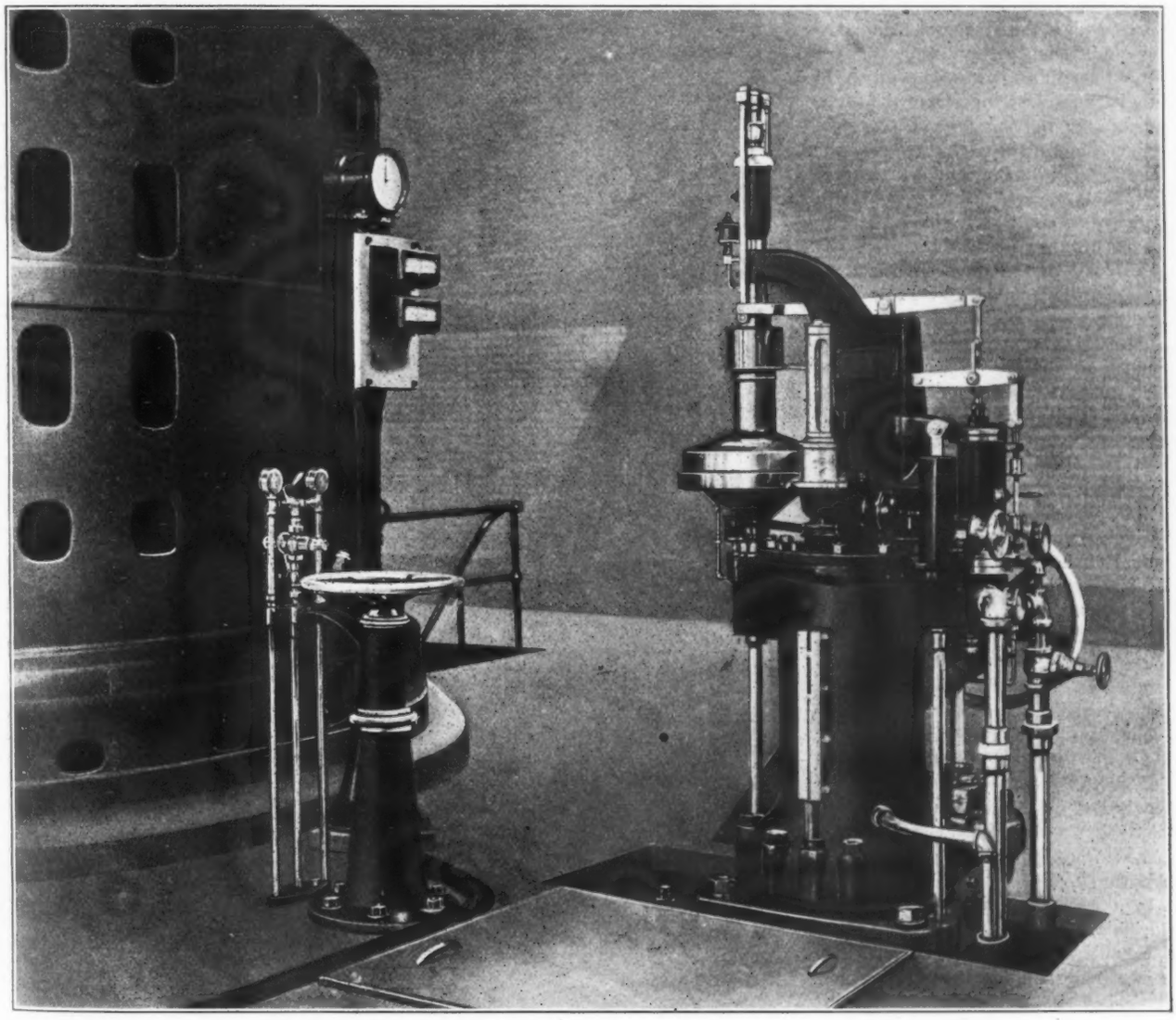


FIG. I. THE GLOCKER-WHITE TURBINE GOVERNOR

makes it impossible to deal with the water as one would with steam; that is, reduce or increase its flow at will. If the flow is abruptly reduced, the effect known as water hammer is brought about, and energy of the moving water in the penstock is to increase the velocity through the remaining opening, to a degree which, if the closing is sudden enough, may actually, for the moment, increase the speed of the wheel instead of decreasing it as would be expected. An abrupt opening of the gate is followed by an opposite its velocity to the varying openings of the gate, but it is impossible by means of the governor alone to provide as quickly for changes of load with water-wheels as with steam engines. In other words, in water-wheel governor designing it is necessary under the usual conditions to abandon at the start the attempt at close regu-

*Chief engineer, hydraulic department, I. P. Morris Company.
†Assistant to Mr. White.

lation through quick movement of the gates; and to introduce an interval of time between a large change of load and the recovery of the speed to the normal figure.

Action Under Actual Conditions

While this seems in the stating of it a serious defect, it ceases to be so under actual conditions. The difficulties introduced by long penstocks are counteracted by the fly-wheel effect of the revolving parts of the generator and turbine, which tends to maintain the speed constant under sudden variations in load until the governor has had time to move the turbine gates and to bring the water in the penstock to the required velocity. In certain high-head installations having long pipe lines and high-speed units, it is necessary to equip the turbines with fly-wheels and relief valves to make close regulation possible. In such a plant as the one to be described, however, the enormously heavy revolving parts possess sufficient inertia to enable the governor to regulate the units without difficulty. Large electric plants, such as those for which the governor to be described is intended, supply current for many users and for many purposes, and the actual changes in the load are usually gradual, so that, in point of fact, the governing becomes practically equal to good steam-engine practice. The real effect of this design is to introduce a safety feature against possible abrupt changes of load and at the same time to combine the essential properties of a sensitive and an insensitive governor; that is, the accurate regulation of the former and the stability of the latter, the hunting action which naturally goes with sensitive governors of the usual type being entirely avoided in this design.

A Plant to Which the Governor Has Been Applied

It should be understood that this governor is a special design, intended for special conditions. It is necessarily an expensive construction and not intended as a competitor of the many excellent commercial governors on the market. Governors of the type shown were applied to the four 13,000-horse-power and the two 500-horse-power turbine wheels, designed and built by the I. P. Morris Company, of Philadelphia, for the Electrical Development Company, of Ontario, Canada. In this Niagara installation the turbines are on vertical shafts and are located about 150 feet below the power-house floor, the governor being located on this floor near the generator. The water-wheels are of the double-casing, double-runner, single-draft-tube type, having cylinder gates, which are operated by levers and rods, the weight of these gates, levers and rods aggregating some 15,000 pounds, which, in addition to the frictional resistance and hydraulic pressure on the gates, must be handled by the governor. The weight of these parts is made to close the gates, the governor being of the one-way type; that is, the cylinder which, by means of high-pressure oil, operates the gates, and which is controlled by the governor, is single acting, the pressure being used to open the gates only, while the escape of the contained oil from the cylinder is made to control the action of the heavy parts in closing the gates.

The Operation of the Governor

Fig. 1 shows the governor as installed, with its generator at the left, and Fig. 2 is a section of the revolving element. In order to give a general idea of the principle on which the governor operates, it may be explained that the revolving element, which is geared to the turbine shaft by a positive drive, is the part of the governor which responds to changes of speed of the turbine and directs what position the turbine gates should occupy. It does this by moving the sleeve *i*, Fig. 2, on the central spindle and with it the floating lever *a*, Fig. 4, as will be explained. The function of all the rest of the mechanism of the governor, shown in Fig. 4, is

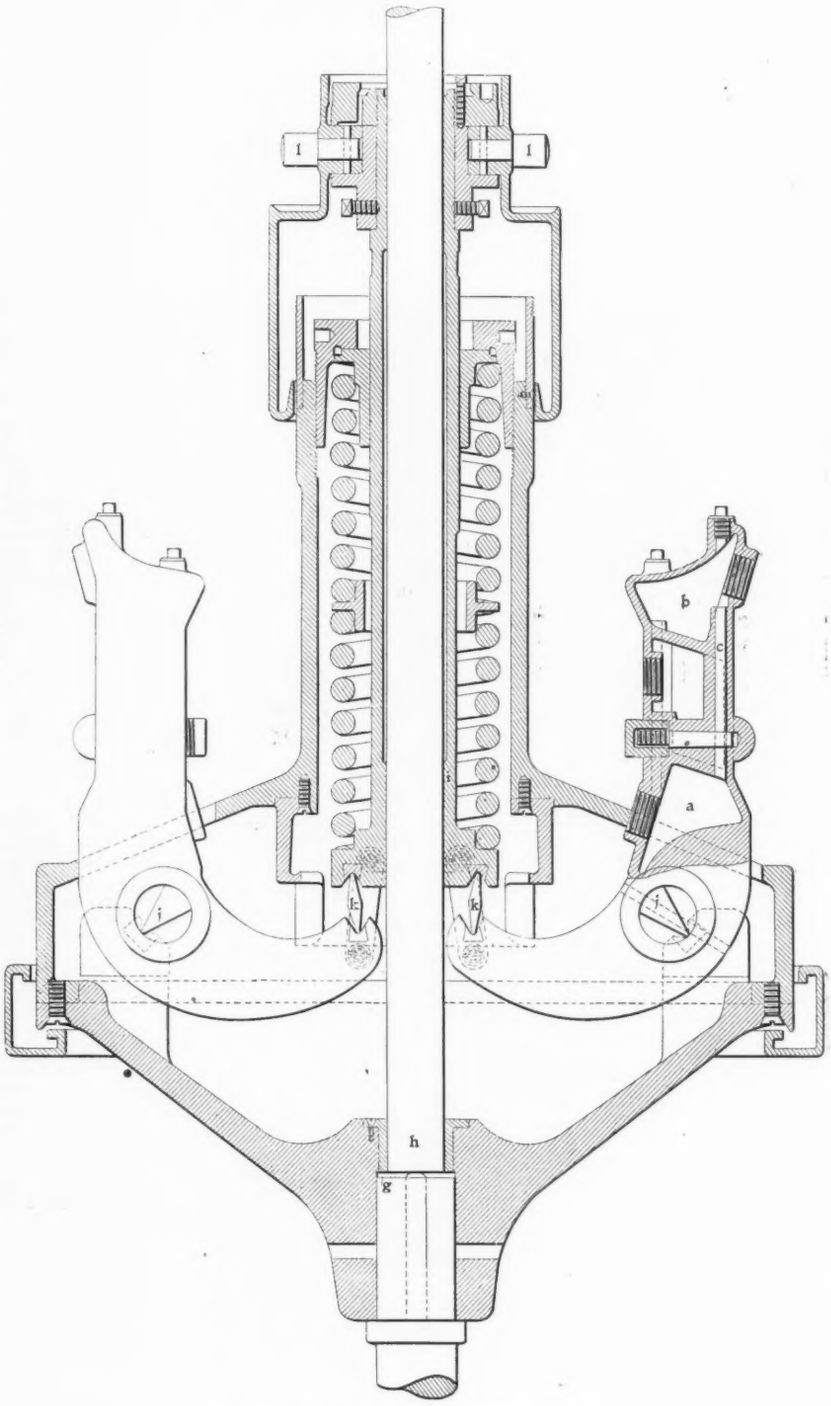


FIG. 2. SECTION OF THE REVOLVING ELEMENT

simply to move the gates into a position corresponding to that occupied by the sleeve *i*, and to keep them there until *i* is moved again. When the fly-balls or arms, Figs. 2 and 3, are vertical, the sleeve *i* and the turbine gates are in mid-position; when the arms approach the center of revolution, due to a decrease of speed, the sleeve moves downward and the governor mechanism opens the wheel gates an amount proportional to the movement of the sleeve; when the arms fly outward, on account of an increase of speed, the sleeve rises, and the wheel gates close a corresponding amount. With the arms in their inner extreme position, the wheel gates are wide open; with the arms in their extreme outward position, the wheel gates are closed.

Mercury-charged Governor Balls

The most novel feature of the governor is shown in Fig. 2; that is, the hollow and peculiar shape of the arms. This feature is, however, shown on a larger scale in Fig. 3, which is a detail of an arm, and shows two chambers, *a* and *b*, connected by a passage *c*, which is intercepted by a plug *d*, having a small hole *e* drilled through it. Into the lower chamber a charge of mercury is placed, and it is the action of this mercury as the arms change their positions which gives the governor its peculiar properties. The normal speed of the governor is 500 revolutions per minute, under which speed the action of centrifugal force is so much in excess of that of gravity that the tendency of the mercury is to assume a position with its free surface nearly vertical instead of horizontal, the theoretic curve of the surface being a paraboloid of revolution; and, under this condition, if the arm is vertical, as it is at normal speed, the mercury will flow through the passageway and be divided between the upper and lower chambers, an air passage *f* permitting free flow. With the mercury in this position and the arms revolving at normal speed, the centrifugal force is just sufficient to balance the action of the spring and maintain the ball in the vertical position. Should, however, the speed increase and the balls move outward, the mercury will partially or wholly move to the upper chamber at a rate determined by the size of the opening *e*, in the plug *d*; while if the speed is reduced and the balls move within the normal position, the mercury will be partially or wholly transferred to the lower chamber.

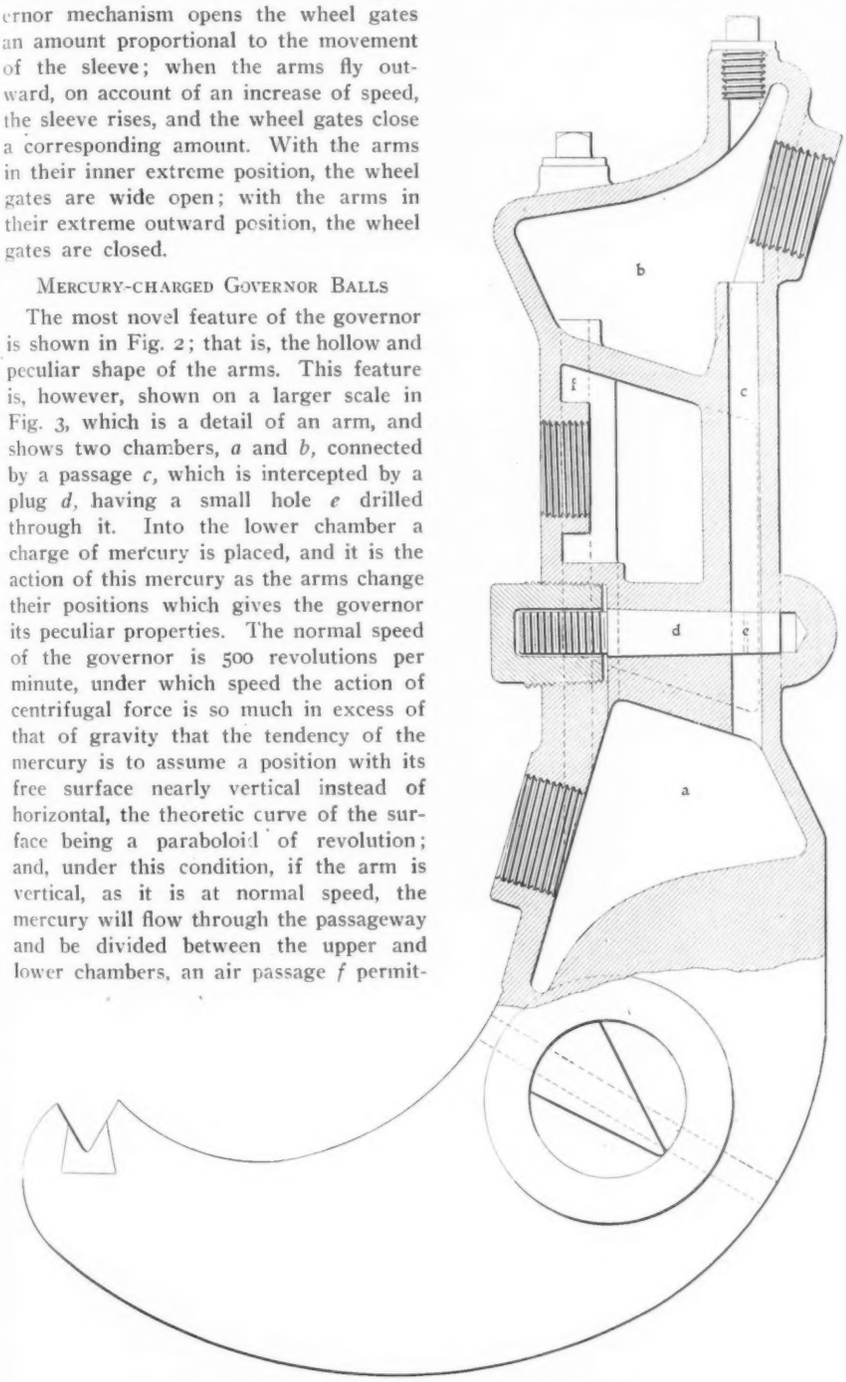


FIG. 3. SECTION OF A GOVERNOR BALL

The Object of the Mercury Charge

If, with the mercury distributed as at normal speed, the passageway *e* could be closed, the governor is so proportioned that it would have a sluggish action, an increase of 50 revolutions per minute being necessary to move the arms to their outer position, and a decrease of 50 revolutions to bring them to the inner position. Under these conditions and without additional compensating devices, the speed would vary from 450 to 550 revolutions from full to no load—this initial sluggish action being the safety device to prevent the water-hammer action.

With the passageway open, however, the action under such an instantaneous throwing off of the load is to make this increase in speed momentary only. With the changed position of the balls the mercury begins to shift its position from the lower to the upper chamber. The centrifugal force of the arm and its charge is increased, less speed is required to maintain sufficient pressure to balance the spring and the speed gradually returns to the normal, or very near it. In the governor shown, the shape of the chambers is such that when permanent conditions are reëstablished, the speed is brought to 495 revolutions under full load, and 505 under no load. The quickness of the recovery is obviously determined by the size of the hole *e* or the adjustment of the plug *d*. This time of recovery is fixed to suit the time required to operate the gates, which in turn is dependent on the length of penstock and on other conditions. It may be remarked in passing that the shape of the chambers is a matter of the greatest nicety and one which it is difficult, if not impossible, to work out mathematically, the shape shown having been arrived at after many preliminary experiments. It is entirely feasible so to design the shape of the chambers as to make the governor perfectly isochronous, or even to make the speed of the turbine considerably higher at full load than at no load, which produces an effect similar to overcompounding a generator in electrical practice. In ordinary practice, and necessarily when the turbines drive alternators, the no-load speed is higher than the full-load speed by a definite amount.

As has been explained, with plants of the size which we are considering, the instantaneous application or release of the load seldom occurs. Under actual conditions the movement of the mercury is nearly in unison with the change in speed, being adjusted to lag slightly behind the speed change, so that after the initial movement of the arms caused by a sudden change of load, the flow of mercury will keep step with the change in speed, the arms remaining nearly stationary until the regulation is almost completed.

Absence of Static Friction

An interesting result of the design of the revolving head is the entire absence of friction of rest. Thus, referring to Fig. 2, the driving shaft is cut off at *g*, the spindle *h* being supported stationary at its top end, the sleeve *i* revolving upon it. The reader will recall how readily a heavy revolving shaft having end play, such as that of a motor or generator, may be moved in its bearings while in motion, although to move it when standing still would require considerable effort. The

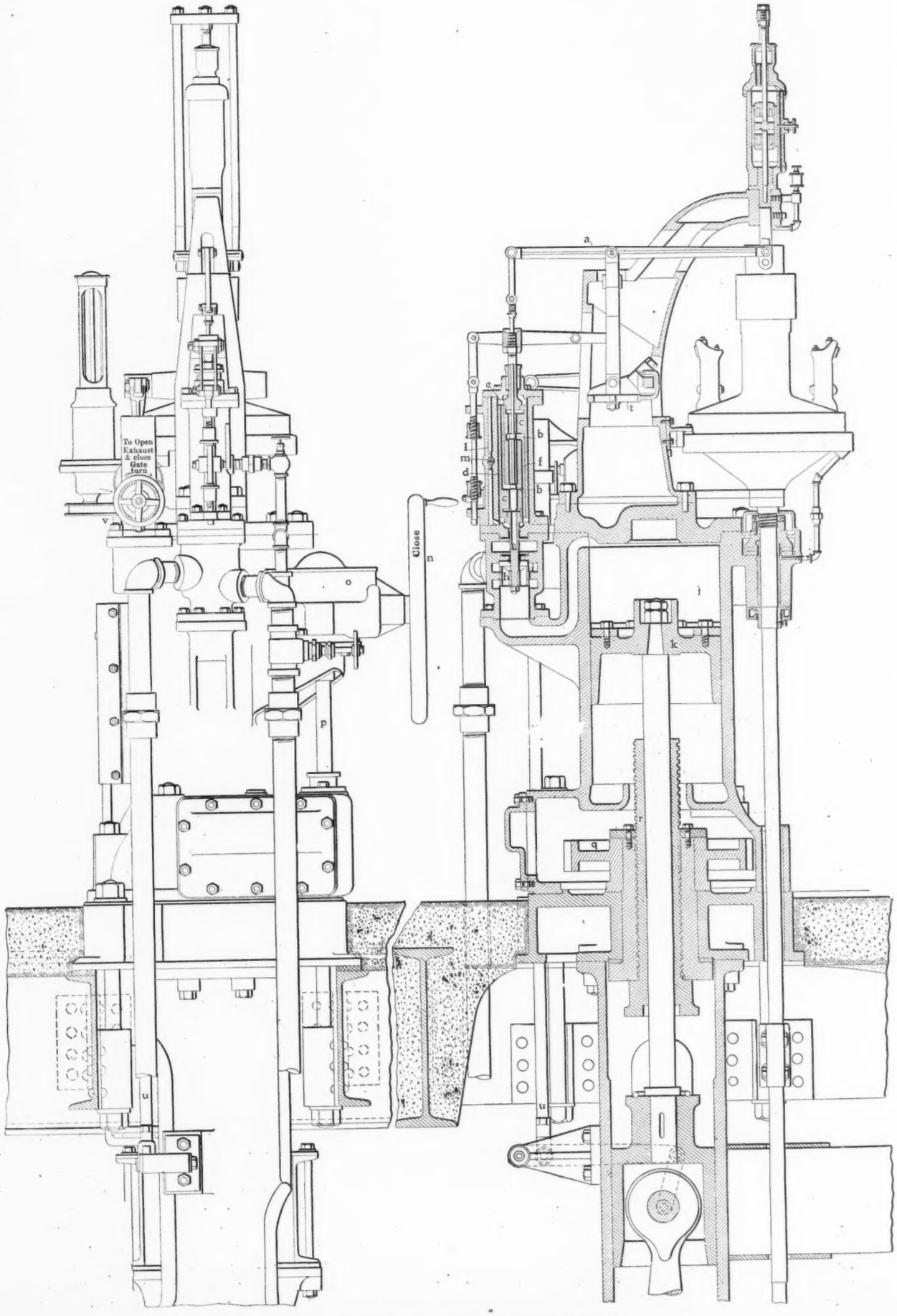


FIG. 4. SECTIONAL ELEVATION OF ENTIRE GOVERNOR

mounting of the revolving sleeve upon a stationary shaft is an application of the same principle, and gives the governor at this point entire freedom. In addition to this, all moving parts are fitted upon knife edges, as shown at *j* and *k*.

The Relay Apparatus

The control of a gate apparatus weighing 15,000 pounds, to say nothing of the rushing torrent of water, by such a delicate piece of apparatus, is, of course, only possible on the relay principle, and, as a matter of fact, in this case the gate control includes a double relay. The mere shifting of the valve for the main gate-controlling cylinder by the governor direct would impose altogether too heavy a load on the balls, and hence this valve is controlled by a supplementary piston, of which the valve is in turn controlled directly by the governor balls. The pistons operate under oil pressure at 250 pounds per square inch.

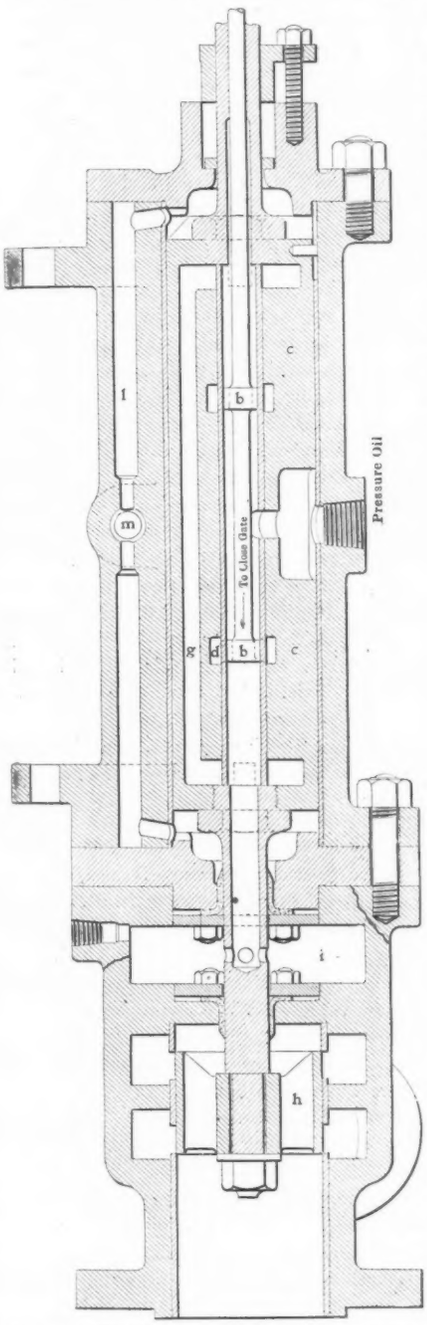


FIG. 5. ENLARGED SECTION OF SUPPLEMENTARY PISTON AND VALVE

Fig. 4 shows the entire governor, except for the revolving element, in section, the rising and falling of the sleeve *i* of Fig. 2, which, as shown in Fig. 4, is fitted with a dash-pot at the top, being made to connect with lever *a*, Fig. 4, by means of pins *l*, Fig. 2. This lever connects with the pilot plug valve *b* of ¾-inch diameter, by which the gate is primarily controlled. The valve works in a long piston *c* having its own valve seat within it, as shown. The pressure oil is admitted to the space between the valve-plug heads, as shown in Fig. 5, which is a section at right angles to the one shown in Fig. 4. Assuming the speed to increase from a reduced load and the balls to go outward, the result will be to depress the valve *b*, and thus admit oil to the port *d*, Fig. 4, and to the upper end of the cylinder at *e*. At the same time the exhaust oil from the lower end of the cylinder will be discharged through the ports *f*, Fig. 4, and *g*, Fig. 5. Under this action the piston will go downward and thus close the port *d* just opened by the lower head of the pilot valve—the piston following the movement of the pilot valve and of the governor balls exactly as though attached to them mechanically, except, of course, after a small lapse of time.

Piston *c* is connected with the main valve *h*, as more clearly shown in Fig. 5, and, obviously, the sinking of piston *c* thus opens port *j* and permits the oil in the cylinder *j*, Fig. 4, to escape and the piston *k* to rise under the weight of the gate parts and thus to close the gate.

Equalizing Mechanism

With the mechanism arranged as described, and without any additional attachment, a movement of the governor sleeve and the end of the floating lever *a* would simply open the admission or exhaust connections of the operating cylinder *j*, and the gates would move to the extreme end of their stroke. In order that the motion of the gates should cease when they have reached a position corresponding to that of the governor sleeve, the fulcrum *s* of the lever *a* is not fixed, but movable, being attached to the equalizing mechanism, which includes the rocker arm *t* and the rod *u* geared to the wrist pin of the gate mechanism. By means of this mechanism, when the gates have moved a sufficient amount, the fulcrum pin *s* moves the floating lever *a* and restores the pilot valve *b* to its neutral position, thus stopping the motion of the gates.

By altering the adjustment of the equalizing mechanism the position of the gates can be altered while the rest of the governor mechanism remains in the same position; in other words, the governor can be made to regulate the turbine at a different speed. This adjustment can be altered by turning the small hand-wheel *v*, and can be controlled from a distant point such as the switchboard by means of a small motor. This distant control is useful in starting and synchronizing the units. An adjustment of the effective length of the rocker arm *t* is provided for the purpose of altering the variation between the no-load and full-load speeds.

A passage *l*, Figs. 4 and 5, closed by a plug cock *m*, connects the two ends of the first cylinder, its office being to throw the governor out of action by opening the cock in order to permit the operation of the gate by hand. This operation of the gate is accomplished by the hand-wheel *n*, Fig. 4, which, by means of bevel gears within the casing *o*, turns the shaft *p* and thus the gear *q*. The hub of this gear is threaded internally and operates the screw *r*, which is mounted upon the gate rod. It will be understood, of course, that this rod is connected to the actual gate mechanism by a lever not shown, which reverses its motion, the pressure of the oil on the upper side of the piston *k* serving to lift the gate and its escape to close it as already described. The gates may also be operated by hand control of the oil admission to the upper valve.

The governor as a whole is seen to be a complicated piece of machinery. Much of this complexity is made necessary by the large number of adjustments required, and by the nature of the operation of governing, which is so far from simple that such a governor as this has been thought to display almost "human intelligence." That the large number of the working parts has not interfered with the operation of the governor is proved by its very successful performance as actually installed.

Civil Service Examinations

The United States Civil Service Commission announces the following examinations:

On August 26, to secure eligibles for the position of janitor-engineer, at $900 per annum, in the court-house and post-office buildings at Salt Lake City, Utah. Application form 1052 will be required.

On September 2 and 3, to secure eligibles for the position of inspector of mechanical and electrical engineering, at $2190 per annum, in the office of the Supervising Architect, Treasury Department, Washington, D. C. Application form 1312 will be required.

To keep the oil of hanger-boxes from crawling a shaft, clamp a bit of wire between the ends of the hanger-boxes and caps, with the wire bearing on the shaft bent so as to steer the oil back into the box.

City Supervision of New Boiler Plants*

By Paul P. Bird

Smoke prevention has become so important and necessary a work in the larger cities where soft coal is chiefly used that carefully planned organizations and well thought out policies are required to handle the work successfully. There are a number of cities in the middle West where this is true, and in these cities the work of smoke abatement, as far as the city government is concerned, is no longer a one-man proposition, but requires a smoke-inspection department of considerable size.

The subject is so complex and so difficult that a successful campaign against the smoke nuisance must be carefully planned and consistently and often laboriously carried out. Probably one of the most necessary things, and the thing that is most often overlooked is a thorough realization of the fact that the work of smoke abatement, as the problem is presented to us today, is a task that is huge, and the results will come slowly.

Proper Enforcement of Ordinances

A city cannot simply pass a smoke ordinance, appoint a smoke inspector and then sit still and expect the atmosphere to clear up. The proper enforcement of a smoke ordinance means that citizens must be stopped from doing something which they have always considered that they have a perfect right to do. To this end it is absolutely essential that a smoke inspector have the backing of a well-formed and strong public opinion. Without this he can do nothing. In most modern cities the people get what they want. No more, no less. If the people want the smoke eliminated, seriously and conscientiously want it, then a smoke inspector can do something. On the other hand, if a strong public sentiment in favor of smoke abatement is not aroused, it is a difficult task indeed. The public must understand also, to some extent, that the smoke is not to disappear all at once; that it will take time; that the city authorities must keep everlastingly at it and that it is everyone's duty to do his share of the work.

A city with an atmosphere laden with soft-coal smoke cannot become clean all at once. It will take time, and it can only be brought about by following out a policy that is founded on correct principles. We all know pretty thoroughly the abstract principles of complete and smokeless combustion. We know that when we universally accomplish these conditions we will have no smoke. Therefore, we must adopt the policies that will soonest bring about these conditions.

How to Have a Clean Chimney

To have a clean chimney when burning soft coal means: first, a carefully designed plant, with particular attention paid to the furnace and other parts that affect its smoke-making characteristics; and, second, the plant must be carefully operated.

Some firemen will continue to be as unreliable and as lazy in the years to come as we find them today. Therefore we must turn our particular attention to the design of the boiler furnace and eliminate as far as possible the personal factor of the fireman. Let us make the furnace fool-proof if we can. The object of this paper is to discuss the means that a city government may use to get only the best plants installed in all cases.

Some people believe that they have a perfect right to put in any sort of a boiler furnace that they may fancy, but when the subject is carefully considered and the importance of the smoke problem realized, another conclusion is reached. For years city governments have controlled the erection of certain classes of building within fixed fire limits; they have made and enforced building ordinances which have insured that buildings were strong enough to support the designed load, and have insisted on numerous regulations for fire protection. Similarly regarding sanitary arrangements. Health officers have enforced rules providing for healthful and sanitary equipment in new buildings.

The Chicago "Smoke Ordinance"

In view of this, the city council of Chicago, about one year ago, passed a smoke ordinance which provides that the plans and designs of all new plants or the installation of old plants for producing power or heat must be approved by the smoke inspector before the work of installation or repairs is commenced.

It further provides that the smoke inspector must issue a permit for each job. This permit signifies the approval of the design for the furnace, breeching and stack. The permit, for which a fee of $2 per plant (not per boiler) is charged, is issued when the drawings are presented and before the work is started. After the work has been finished, but before the boilers are started up, a representative of the smoke department inspects the work to see that it has been done in accordance with the plans passed upon, and a certificate allowing operation is issued.

This section of the ordinance has been in force since the middle of September, 1907, and today it is believed by those in charge of the Chicago smoke department that this provision is of the utmost importance in the work of cleaning up the city's smoke. It is believed that if a similar ordinance had been in force in Chicago for 10 years and had been carefully and rigidly lived up to, the present smoke would have been reduced by 75 per cent. A policeman may go out and observe violations of the smoke ordinance, may bring suit and in this way reduce the smoke to some extent, but no permanent and lasting improvement will be made until all new plants that go in are carefully studied and the best means provided to reduce the smoke. Naturally, when everyone in a city, who is selling boilers or furnaces, understands that the plant which he offers to install must pass the city smoke inspector, he bids upon apparatus which he knows will meet with such approval. If the smoke inspector is careful at all times, keeps every one up to a high standard and treats everybody fairly and impartially, then it means that every plant which is installed can be safely operated without danger of making objectionable smoke.

It is not an easy task to pass on drawings as outlined above. It requires a well-informed engineer to do it and a man who is eminently fair minded and honest. This is so, because he is continually running up against private interests, and the inspector has need of all the tact and diplomacy that he can master.

Smoke-prevention Devices

There is another phase of the question which is of great service to the citizens. There are on the market today a great many so-called smoke devices which are merely make-shifts and possess no particular value. The layman who is not an expert engineer but merely a business man, is at the mercy of the salesmen of smoke burners, preventers or devices, as the name may be. A city official who must give his approval of new installations, can save the citizens from foolishly spending their money for something which is not worth what the salesman claims for it and which will not do all that the salesman represents. The Chicago smoke department has taken the stand that no make-shift installations will be allowed. A furnace must be well designed on broad lines and no jobs will be passed that are fundamentally wrong.

It is surprising to find, in a city like Chicago, how many new steam plants are put in within a short time. The present smoke inspector's experience has been that almost every plant in Chicago, which has given him serious trouble, has been installed within 10 years.

*Abstract of a paper read at the third convention of the International Association for the Prevention of Smoke, Cleveland, O., June 24, 25 and 26, 1908.

Construction of Furnaces to Meet the Requirements of the Chicago Smoke Department *

By Robert H. Kuss

For the setting of return-tubular boilers, irrespective of size, pressure, or fuel to be used, the department of smoke inspection requires that, hereafter, the furnaces shall be made so as to inclose the grate and the region immediately above it, in fire-brick. There are a number of furnaces on the market which fulfil the requirements mentioned above, that is, that the furnace shall be fire-brick inclosed. The smoke department urges, when considering the installation of boilers, that the several furnaces on the market be investigated. In the event that one of these furnaces is selected, the department of smoke inspection still will regulate certain features in the proportions, so that a reasonable performance may be expected from the furnace selected. It will also endeavor to protect the owner from mistakes due to faulty construction, and will use as much care as is necessary to see that all the features of capacity, economy and smokelessness are conserved in each case. In general the following requirements will be insisted upon:

The furnace is to be equipped with doors that allow the admission of excess air over the fire, when desired. The McGinness door is an acceptable one, though this is not the only one that is acceptable. In the event that an ordinary solid door with a small register is employed, it will be necessary to remove from the casting a rectangular piece as large as is practicable, and will require that a vane is swung in the place of the piece cut out. This vane is to be so hinged that it may be adjusted in any desired position.

If it is proposed to use a system of automatic steam jet and automatic air admission in the place of special doors, there would be no objection, and it is to be remembered that such a system may be of assistance and may make the installation more secure.

The fire-brick over the door-opening liners shall be arched and sprung free of the liner itself. The front wall of the furnace shall not be less than 18 inches thick, and the brick therein shall be first-grade fire-brick throughout, up to the line of the main arch of the furnace. In furnaces 48 inches in width or less, the main arch may be 4½ inches in thickness, but above this width the arch must be 9 inches in thickness. The arch system must extend beyond the back face of the bridge-wall, the distance depending upon the size of the furnace.

The bridge-wall must be made with first-grade fire-brick, solid above the grate line and faced not less than 9 inches thick below the grate line extending to the combustion chamber floor. The lining of the furnace proper, meaning the side walls below the main arch extending to the grates in front of the bridge-wall and to the floor of the combustion chamber behind the bridge-wall, shall be 9 inches in first-grade fire-brick.

Above the main arch of the furnace and behind the furnace proper in the combustion chamber, the lining may be 4½ inches in first-grade fire-brick, with headers every fifth row, but must extend to the combustion-chamber floor. The combustion-chamber floor is to be paved with fire-brick set on edge, but this fire-brick may be seconds or old first-grade fire-brick previously used.

Blow-off protection is not regulated in any respect by the department of smoke inspection, this matter being left to the department of steam-boiler inspection.

In order to secure the main arch and prevent its falling down, it is necessary to insert into the side walls either I-beams or channels with the metal exposed to the outside, these beams to be held in place by the vertical buck stays. The air space in the region in which the thrust of the arch comes should not be employed.

Attention is here called to the way in which the arch meeting the rear tube-sheet should be constructed. Any exposed metal system should be rejected. The Hartford method of springing the arch from side to side is preferable to the system of springing the arch from the rear setting wall to the tube-sheet. The selection of a boiler with the manhole in the rear tube-sheet will not allow the use of the Hartford arch, and this point should be borne in mind. Where in the judgment of the department it is advisable to employ a deflection arch behind the main arch of the furnace, such will be insisted upon.

It is not within the province of the smoke department to insist that furnaces shall be extended in front of the boiler line, but it recommends that in all cases where it is possible to do this, the extension furnace should be adopted.

It will be noted that in the important point of extension furnaces, the department is not committed; on the other hand, there is no back-down in the matter of furnace design. In the case of extension furnaces an insulating arch must be employed. Where some form of automatic fuel feed is used, a deflection arch behind the main arch is not always insisted upon, though it is seen to that this may be inserted afterward in case of an unsatisfactory performance without.

Based upon the advice of the board of advisory engineers, we endeavor in all cases to obtain as much as 7 feet of distance for gas travel, measured from the place where fresh fuel is fired upon the grates to the region where the gases reach heat-absorbing surface. This applies to all forms of furnaces, both hand-fired and stokers.

For traveling grates, we make the following minimum requirement: When it is proposed to use a mechanical stoker of the traveling-grate type, the minimum which the department will consider favorably is an arrangement where the brick arching above the grate or its equivalent extends to a vertical line drawn from the front face of the bridge-wall. The hight of the bridge-wall should not be less than 16 inches, more being desirable. The area over the bridge should be not less than 30 per cent. of the effective grate area.

Mechanical fuel feeders must always be equipped with arches. Scotch marine boilers are always equipped with extension furnaces, and the minimum apparatus found to be successful has been a gravity-fed furnace, and then only with excellent draft facilities. The under-feed stoker has answered fairly well with the Scotch marine in the few cases under observation, at least during the periods when the furnaces are running normally.

For double-inclined stokers, we endeavor to have extension furnaces in all cases, because then it is not necessary to depend upon the unsatisfactory method of firing through the front magazine door, which necessitates pushing the coal to the back part of the magazine. A great deal of the trouble occurring with this form of stoker is attributable to this cause alone, because the service is intermittent.

Water-tube boilers present the same problems as fire-tube boilers, and even with the tile roof are not necessarily successful. Much depends upon the facilities for removing soot and fine ash from the tube regions.

Manifestly, a rigid enforcement of the law relating to performance is the greatest contributory factor in causing the prospective owner to become anxious to install adequate apparatus. Bad records of the performances of apparatus he proposes to install in a new plant will indicate to him the fallacy of starting on a career of trouble, and affords the department an argument that cannot be refuted. We are gradually working around to a system of close tabulation of the performance by different forms of apparatus, believing that such a record will not only be convincing to the public, but will serve to aid us in the study of what to expect of certain types.

After installation the work of inspection shows that originally there was little attention paid to workmanship or materials, dimensions were not closely followed and everything about the jobs was slipshod and careless. Gradual pressure and checking up has resulted in better workmanship, better materials, a more wholesome atmosphere in the trade, a stricter definition of responsibility, and certainly a better return for the outlay.

*Abstract of a paper read at the third convention of the International Association for the Prevention of Smoke, Cleveland, O., June 24, 25 and 26, 1908.

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The index to Volume 28—January to June, 1908—is now ready and will be sent to any subscriber on request.

Engineers Must Study to Keep on Top

Incentive for the operating engineer to study was never more apparent than now; nor in all the history of the art of steam engineering could the results of intelligent study be made more profitable. Development in the use of electric current for power and light gave a tremendous impetus to the business of building steam engines and kindred apparatus, and the steam engineer became an important factor in the world's work in consequence.

While the engineer was growing and his vocation was demanding daily a higher grade of skill and a better trained mind, the followers of other trades were being rapidly relegated to the ranks of unskilled workers. The horseshoe-nail machine, the horseshoe machine and the drop hammer performed the work of thousands of blacksmiths, and while a few became attendants of machines, many were forced into other walks in life. The sticking machine and similar appliances have shrunk the carpenter's mammoth tool chest, with its multiplicity of molding planes and special tools, to a little box of the commonest kind of tools that almost any unskilled worker may use. The shoemaker's bench and his few simple tools have given place to an aggregation of complex machines that require a great factory building for their accommodation, and the shoemaker as an individual is lost—an atom swallowed up in the complex process of modern commercial production.

Until recently the engineer has felt secure in his calling, as no machine had been devised that would supplant his skill. He has felt that no machine nor arrangement of machines, large or small, would ever be made that would change him from the alert, clear-eyed supervisor of power-plant apparatus into a dull and listless, unskilled laborer, ministering to the needs of machines which he did not understand and in which he took no interest. But the machine that is to compete with the engineer is finished, and its owners are hunting work for it. It is the central station, and solicitors are visiting every power plant in the land, showing the proprietor, truly or otherwise, that with the advantages of cheaper fuel, more efficient engines and larger output per man employed, it is a better business proposition for the small-plant owner to buy his power, and have it night or day, Sunday and holidays, than to attempt to make it himself. That the solicitor is often successful in his work many an engineer has learned to his cost.

Many changes of this kind have been made where, had the engineer applied himself to the study of the conditions in his plant and been able to show to his employer how the cost of operation was distributed—the coal and water for heating, coal and water for power and lighting—and had acquired a speaking acquaintance with the cost of operation in each department, as compared with the cost in other departments, the results, instead of being reduced pay or enforced idleness, might have been better pay and lighter work.

Fads and Fancies of Gas Power Champions

A few years ago some misguided salesman dealt the gas-power industry a heavy blow "on the wind" by stoutly asserting that his engine required absolutely no attention beyond starting it up and shutting it down, except to keep the oil cups filled; a rival improved on this by omitting the oil-cup stipulation. This reckless claim was immediately duplicated by practically all the other manufacturers, and the gas engine is just beginning to recover from the effects of it.

Next came the fuel economy man—"one pound, one hour, one horse-power" was his alluring slogan. That wasn't so harmful because it was only an exaggeration, and the actual economy is high, even in poor examples. But they all got the habit, and for months they rung the changes on the fuel-economy platitude.

Next came the fuel-economy man—"one It is the fashion, whenever a paper on gas power is read or discussed before an innocent gathering of electrical engineers, or other uninitiates, to look wise and say, with the air of one who has discovered a new chemical element or a comet, that a steam engineer does not make a good gas engineer. On the contrary, any bright youth, with three hours and forty-two minutes of careful training (here the speaker looks modest, to indicate who knows how to give this training) will do much better. As to boiler firemen for producer work—why, any hod carrier will do better.

Now the simple facts—proven over and over—are these: Gas engines and producers do require skilled attendants; the necessary degree of skilfulness is no higher than that required in a steam plant, but it is along somewhat different lines; a good, ambitious steam man will make a satisfactory gas-plant man in less time than any other class of novice; a rutty, fossilized steam engineer opposed to progress or change of any kind is the worst possible material from which to make a gas engineer. To the last of these four facts doubtless was due the origin of the habit of broadly condemning steam engineers as gas-plant attendants, but while this may be an explanation it does not constitute a valid excuse.

Factors Governing Intensity of Draft

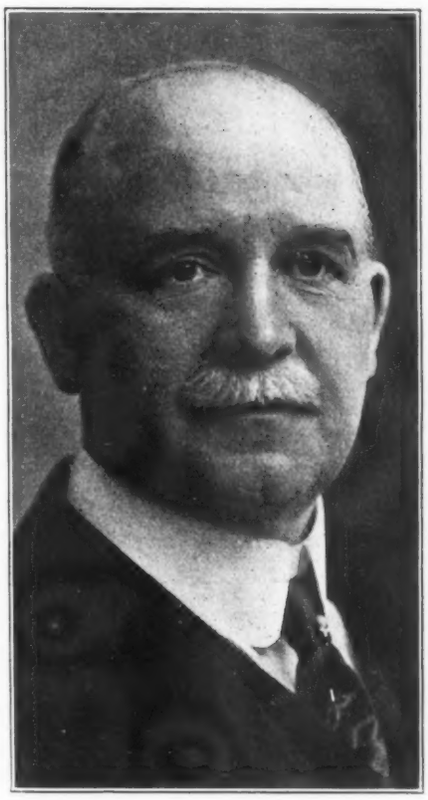
In increasing the boiler capacity of a steam plant a second boiler was placed at some distance from the first and connection made to the side of the stack which was over the first boiler. The old stack, which was regarded as too small for both boilers, was replaced by a larger one ten feet shorter than the old stack. Complaints came from the boiler room that the old boiler did not steam as well as before. This is just what might have been expected. Intensity of draft is due to the difference of weight between the column of hot gases inside the chimney and the cooler air outside. From complex formulas relating to chimneys and drafts simple rules have been derived which are accurate enough for use in simple cases. The intensity of the draft in the case mentioned depended upon two factors, the hight of the stack and the temperature of flue gases. Reduction in the hight of the stack reduced the value of one of the factors in draft production; reduction in draft probably lowered the temperature of the flue gases, and a double reduction of efficiency in the chimney was the result.

Lubricating Gas Engine Cylinders

An explanation is going the rounds as to the cause of the return to the shops for re-boring, after a short time of service, of some large gas engines recently installed in a steel works. The engines were equipped with positive sight-feed lubricators timed so as to inject the oil between the rings of the piston as it passed on its exhaust stroke, thus giving the greatest length of time for the diffusion of the oil before the next explosion. This system requires, of course, that there shall be a solid column of oil between the pump plunger and the point of delivery, in order that the application of oil may take place promptly at the point in the stroke for which the actuating mechanism is set. All of this well-devised scheme was set aglee by the interference of one whose interest and intention were highly commendable, but who unfortunately lacked an intelligent grasp of the subject. Thinking to leave no stone unturned and no step untaken which might aid in making the installation a success, and knowing that an air chamber is a good thing on a pump delivery, this ambitious practitioner fitted the oil pumps, which should have been positively timed in their delivery to the hundredth part of a second, with air chambers which introduced into the system all the elasticity of a volume of air at varying pressures. As a consequence the pump fed oil into the delivery pipe until it had compressed the air in the chamber sufficiently to raise the delivery valve, which might happen most any time with reference to the stroke or cycle, and would never happen when the piston was over the delivery end of the pipe, as it should be when the oil escapes. When the valve was lifted the compressed air squirted the accumulated oil out into the cylinder, where it was as likely to arrive while combustion was going on as well as at any other time, and to add fuel to the flame, but to lose its efficacy as a lubricant. The consequence was that the massive cylinders had to be returned to the shop after a few weeks' run, involving not only the direct expense connected with such return and repair, but an interruption of service and an apparent failure for the gas engine, of which its opponents will not fail to make the most.

Charles H. Dale

Charles H. Dale, the news of whose sudden demise came as a shock to so many of the readers of our last issue, was a remarkable example of what a man with faith in himself and in the products which he represents may become. Some seventeen years ago he approached his fortieth year as trainmaster on the West Shore railroad, where he had previously been a conductor. It is not often that one trained in the servitude and buried in the routine of the work of a big corporation up to his quarantieme, one who has passed the first good half of his business life in working for a trainman's pittance, branches out and inside of a score of years gets to be the recognized head of a great industry and to command a salary twice as large as that of the President of the United States.



THE LATE CHARLES H. DALE
(Photo by Davis & Eickemeyer)

Although "Rainbow" packing is known in every engine room in the land today, it was known to only a small circle of users when, in 1890, one of the gentlemen financially interested in it induced Mr. Dale to give up his position with the railroad and to associate himself with the Peerless Rubber Manufacturing Company. We knew him first as an active, energetic, intelligent salesman, rapidly advancing in influence. In 1892 he appears as general sales agent; in June, 1894, as general manager, and in 1895 as president and general manager.

Once in full command, Mr. Dale forged the Peerless company ahead amazingly. He held his position as its president, as the leading figure in the mechanical rubber-goods trade, not by virtue of any special knowledge of the art of working rubber, but by reason of his ability to sell the product. His motto was: "It pays to advertise." When competitors were "saving money" by using eighth and sixteenth pages, he was using four and five whole pages and selling goods in proportion. His display advertisements were a feature in all the mechanical papers and the Peerless products were distributed by the carload instead of by the case. When the consolidation of the rubber interests came he was able to dictate terms for the Peerless interests and at the time of his death was president not only of the Peerless Rubber Manufacturing Company, but of the Rubber Goods Manufacturing Company of New York, the New York Belting and Packing Company, Ltd., and the Mechanical Rubber Company, and a director of the United States Rubber Company. He had, in the meantime, amassed a large fortune and was a director of the Merchants Exchange National Bank and the Century Bank, a member of the Union League Club, New York Yacht Club, Larchmont Yacht Club, New York Athletic Club, Automobile Club of America, and the Masonic order.

The ten new torpedo boat destroyers are to be equipped for burning oil only. They will be fitted with turbine machinery, with the expectation that the speed will be at least 30 knots, which, it is believed, may be easily attained and maintained with the new characteristics of fuel and motive power. It had not yet been ascertained what will be the radius of a destroyer so equipped, but it has been estimated by the experts that a boat using oil instead of coal will have a radius of one and a half times that of a similar ship burning coal. It has been practically decided that no burner which requires steam or compressed air for atomization of the fuel will be permitted. The oil will be put under pressure and heated before passing through the burners.—*The Engineer.*

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The "Detroit" Water Meter

A new water meter just being placed on the market, and known as the "Detroit," is manufactured by the Central Station Steam Company, Detroit, Mich. It can be used for metering the feed-water used in boilers or the water of condensation from heating systems, etc. It consists of a cylinder drum divided into four compartments, a supply pipe being introduced axially into one end of the drum but not connecting with it. The drum revolves around this inlet nozzle, due to the weight of the water in the different compartments at each succeeding instant. Each compartment has an outlet for discharging its contents at the proper time. The inlet nozzle discharges the fluid from a long, narrow opening along its bottom.

The compartments are filled successively, and when one is completely filled it overflows into the next succeeding compartment. As each succeeding compartment acquires its weight of water, that weight causes the drum to revolve and empty the preceding compartment, which takes its place directly under the discharge from the inlet nozzle and is filled to overflowing, when it passes on and is emptied in the same manner.

By referring to Fig. 1 this operation will be made clear. When the compartment *A* (I) is filled, the water overflows into compartment *B*, which is next in order of rotation. When the drum revolves 10 degrees beyond the position shown in II, compartment *A* is entirely disengaged from the outlet flow and can receive no more water. As the continued revolution of the drum reaches 15 degrees, the outlet of compartment *A* is brought to the level of the water in that compartment (III) and the liquid begins to flow out by gravity into the receiving tank. When the drum passes the 10 degree point beyond the position shown in I, the compartment *B* receives all the flow through the inlet nozzle and is brought in position of balance to be filled and emptied in its turn, and so on from cycle to cycle.

Referring to Fig. 1, view I, shows the drum at a balance until the chamber *A* is completely filled; II shows the chamber *A* overflowing into chamber *B*, and overcoming the balance the drum begins to revolve; III shows the drum having revolved 10 degrees from its second position which completely cuts off the inlet nozzle from chamber *A*. The water in chamber *A* seeks the level of overflow *C*, while the drum revolving 5 degrees more brings the outlet *D* to the same level as *C*.

During this time the water is free to seek a perfect level before beginning to discharge. View IV shows the chamber *A* discharging, while the chamber *B* is filling. View V shows the continuation of the process, indicating how the relation of levels determines the position of the drum. View VI shows the position of the drum approaching the first stage, which completes the cycle.

The general construction of the meter

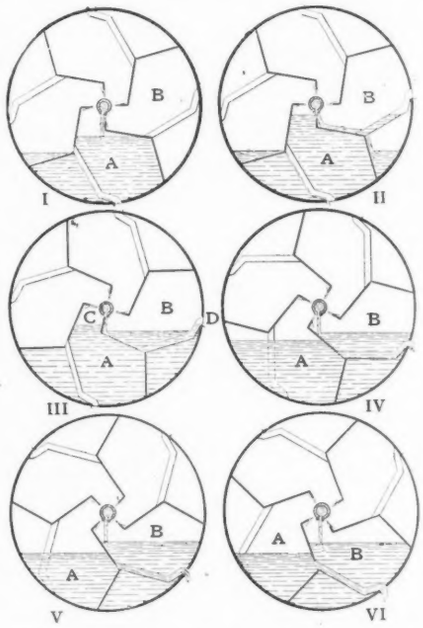


FIG. 1. VERTICAL CROSS-SECTION, SHOWING OPERATION THROUGH ONE CYCLE OF THE DRUM

is shown in Fig. 2, which also shows a typical setting for measuring boiler feed-water. It is seen that the water supply is regulated by means of a float which rests upon the water, shuts off the water supply at a depth of 24 inches and opens the valve regulating the water when it has dropped to a depth of 12 inches.

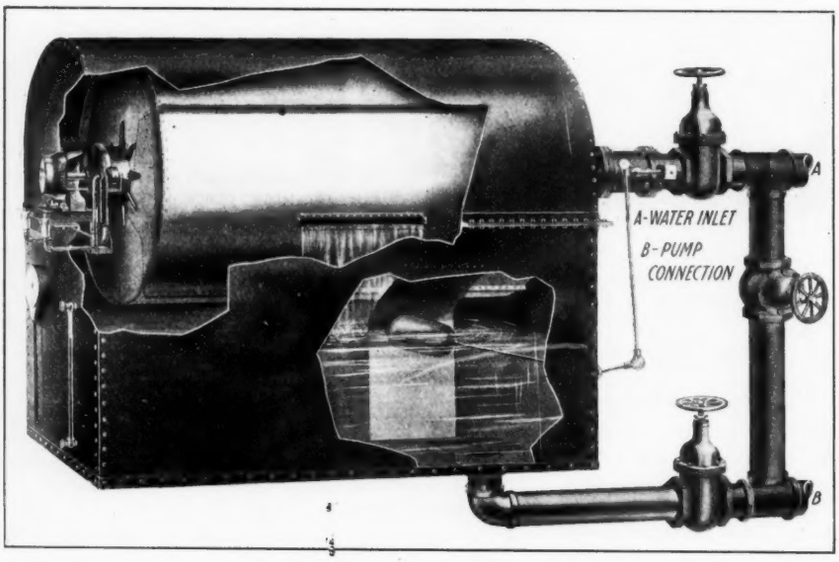


FIG. 2. SHOWING CONSTRUCTION OF THE "DETROIT" METER

Atkinson's Spring Relief Gear for Gas Engine Indicators

This device has been designed as an addition to the gas-engine indicator to relieve certain momentary shocks to which the indicator is exposed at the time of ignition in the cylinder. It is known as the Atkinson spring-relief gear, and is manufactured by Joseph Casartelli & Sons, 43 Market street, Manchester, England.

Figs. 1 and 2 show this device attached to a Casartelli "special" gas-engine indicator and to a Richards-type indicator. The spring-relief gear is definitely fixed in a proper position, to record correctly

the pressure in the cylinder during practically the whole of the revolutions. It has also the effect of reducing the vibratory oscillations usually shown on the diagrams in a very marked degree. Fig. 3 was taken with the Richards type of indicator having a half-inch area of piston and fitted with spring-relief gear, the spring tension being 250 pounds to the inch. Fig. 4 was taken with an ordinary Richards indicator and shows that the ignition of the engine caused serious shocks and strains the levers.

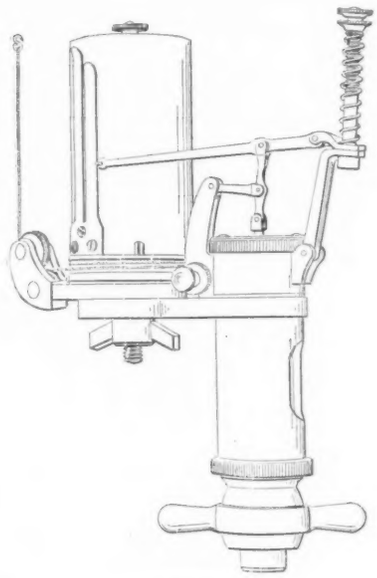


FIG. 1

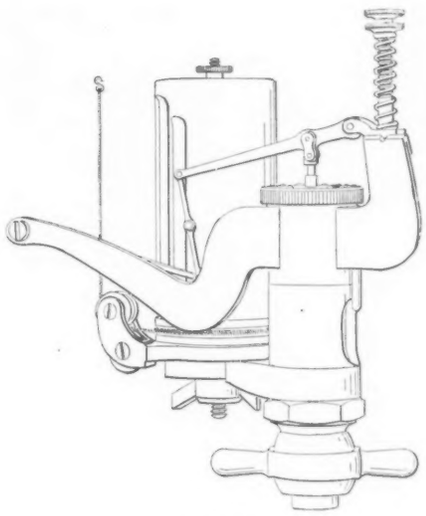
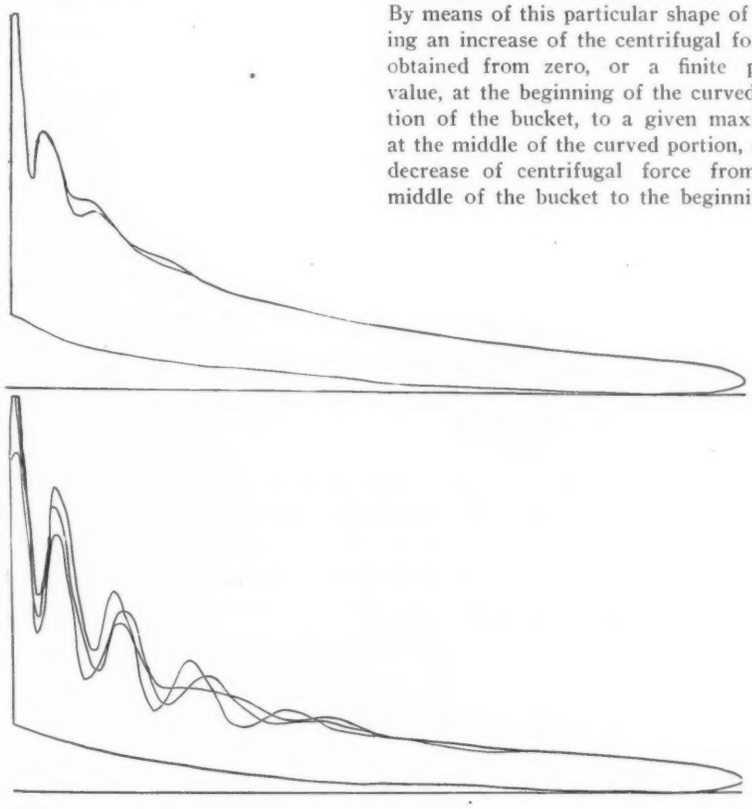


FIG. 2



FIGS. 3 AND 4

Improved Buckets for Steam Turbines

The object of this invention is to provide a bucket so shaped that it will vary the centrifugal force of the elastic fluid flowing through it, preferably in such manner that the increase in centrifugal acceleration and retardation are constant. By means of this particular shape of blading an increase of the centrifugal force is obtained from zero, or a finite power value, at the beginning of the curved portion of the bucket, to a given maximum at the middle of the curved portion, and a decrease of centrifugal force from the middle of the bucket to the beginning of the quitting tangent, where it falls to zero, or a finite small value again.

The result of constructing the bucket on the lines shown in the illustrations is that the steam leaves it in a jet of constant velocity moving in a uniform direction, which renders it of maximum efficiency when directed against the buckets of another wheel.

In Fig. 1 is shown a diagram of a curve composed of a plurality of arcs of equal length described by radii, which forms a harmonic progression of a given initial radius. In Fig. 2 is another diagram in which each radius is seven-eighths of the preceding one. Fig. 3 shows the outlines of several turbine buckets conforming to these curves, and Figs. 4 and 5 are slightly modified, the forms of the buckets having somewhat thicker edges. This design of bucket is the invention of Charles P. Steinmetz, Schenectady, N. Y.

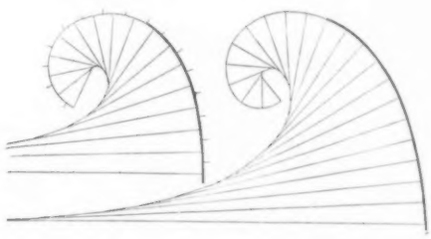


FIG. 1 FIG. 2

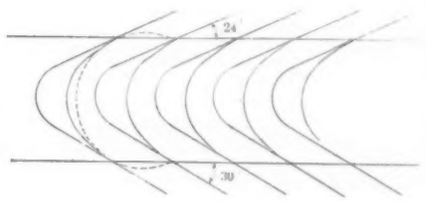


FIG. 3

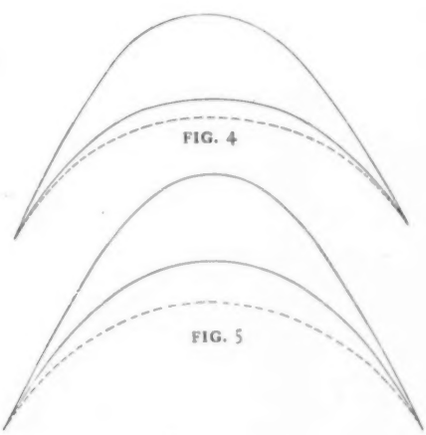


FIG. 4

FIG. 5

In case of low water with fire in the furnace do not draw the fire, as this will intensify the heat and make matters worse, but immediately cover the fire with ashes or fresh coal (wet ashes or slack coal preferred) and close the ash doors. Do not, under any circumstances, turn on the feed water or touch the safety valve. Let all the steam outlets remain as they are until the boiler has cooled off.

Business Items

C. A. Wilkinson, president of the Binghamton Boiler Compound Company, Binghamton, N. Y., whose death occured June 15, has been succeeded by his son, C. S. Wilkinson, in the general management of the business.

C. S. Kiessling, who has been employed in the general offices of the American Steam Gauge and Valve Manufacturing Company for several years, has been transferred to the Chicago office and will have charge of the order department.

The General Electric Company announces recent orders for six vertical Curtis turbine units, 1500-kilowatt, 25-cycle, 2200-volt, each complete with individual base condenser, air and circulating pumps and necessary piping, for the Isthmian Canal Commission.

The Hill Clutch Company, Cleveland, Ohio, recently received an order from one of the subsidiary companies of the United States Steel Corporation for fifty-nine friction clutch pulleys. All of these pulleys are to be of one size and fitted with the new 1908 positive-action Hill clutch.

The Hoopeston Gas and Electric Company, Hoopeston, Ill., recently added to its plant a 280-horse-power Muenzel producer-gas plant, which was installed by the Minneapolis Steel and Machinery Company. This plant has now been in operation for a number of weeks and is said to be giving very good satisfaction.

The Wile gas producers, heretofore furnished by the Wile Power Gas Company, will hereafter be exclusively manufactured and sold by the Gas Machinery Company, which has main offices at 715 to 722 Citizens building, Cleveland, Ohio, the works being at Collinwood, Ohio. Julius I. Wile has been appointed sales manager of the Wile producer department.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Salesmen on commission for New England, Southern and Western States for high grade shaking grates. Box 13, POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one than can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—Salesman on commission for high grade power specialties. Address, stating experience, Chas. T. Luce Co., 160 Congress St., Boston, Mass.

LIBERAL ARRANGEMENTS made with engineers who are willing to devote a little time to handling a high grade, easy selling specialty; no experience needed. Article sells itself. Box 25, POWER.

WANTED—Successful young man of character, energy, ability and experience for sales-manager of concern with ample capital and facilities, located in growing Missouri river city, handling full line of engines, boilers, mechanical goods, mill supplies, belting, etc., and owning large machine shops. Fine opportunity for the right man. State age, references, experience and salary. Address Box 21, POWER.

WANTED, AN ENGINEER—We handle all kinds of mechanical and electrical machinery; controlling the agencies of some of the best manufacturers in the United States and Canada for the province of Alberta and the Kootenay mining district in British Columbia. We have houses at Edmonton and Calgary, Alberta, and Nelson, B. C. We have a position open for an engineer who has practical experience in the above lines, and who also possesses ability as a salesman. This is a spendid opportunity for a capable young man wishing to get a start in the rapidly developing country of Northwestern Canada. Please state your age, experience, reference and salary required in your first letter. Address Gorman, Clancey & Grindley, Limited, Calgary, Alberta, Canada.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Thoroughly competent packing salesmen. The Henry Johnson Co., 175-187 Gates Ave., Jersey City, N. J.

ENGINEER will pay $50.00 commission to anyone who secures or helps him secure a position as engineer, assistant engineer or station man in Rocky mountains West. Box 14, POWER.

SITUATION WANTED—Assistant engineer, married, industrious and experienced, wants a position. New York or Massachusetts preferred. Address Patrick O'Brien, 30 Tuft St., Charleston, Mass.

MECHANICAL ENGINEER wants a change; seven years' experience as superintendent of water works, six years with steam and hydraulic machinery; first-class license; best of references. Box 23, POWER.

POSITION WANTED as chief engineer; experienced with all kinds of engines, steam turbines, a.c. and d.c. generators, motors and switchboards, boilers and pumps; I can get results and furnish the references; have been seventeen years in the mechanical and engineering business. Box 9, POWER.

WANTED—Position as engineer or as foreman of repair shop; experience, four years' apprenticeship to machinist trade, 5 years at marine, stationary and locomotive repair work, and 8 years as engineer at sea; hold U. S. license chief engineer, unlimited tonnages; good executive ability, energetic and experienced in handling of men; competent to take charge of plant, make repairs and run to employers' satisfaction; employed at present, but wishes to make change; strictly temperate; married; age 33. Box 22, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—New or second-hand Turbo generator set, about 50 kw. Box 24, POWER.

IF YOU DESIRE to learn the latest improvement in steam boilers, correspond with the Detroit Water Tube Boiler Co., Detroit.

ENGINES AND BOILERS, ⅛ to 2 h.p. engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make free examination and report if patent can be had, and exact cost.

ALL PRACTICAL ENGINEERS should apply to Wm. O. Webber, Consulting Engineer, 432 Exchange Bldg., Boston, for information concerning tables on all engineering subjects.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-Examiner U. S. Patent Office, 4 Dietz Bldg., Washington, D. C.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass Avenue, St. Louis, Mo.

ENGINEERS, firemen, electricians, machinists, etc. New 25-page pamphlet containing questions asked by the examining boards sent free upon request. Geo. A. Zeller Book Co., 4468 W. Belle Place, St. Louis, Mo. Established 1870.

For Sale

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150 HORSE-POWER tandem compound Corliss engine, in good order; 16-ft. wheel; 24 in. face. F. W. Iredell, 11 Broadway, New York.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—Tenders—Judicial sale of all assets of the Berlin District Steam Company, Limited, of Berlin, Canada. Sealed tenders will be received, addressed to the undersigned Liquidator at his office, No. 58 Wellington street, West, Toronto, Canada, and marked "Tenders in The Berlin District Steam Company, Limited, Liquidation," up to 12 o'clock noon on the twelfth day of August, 1908, for the purchase of the entire assets of the said company now in the possession and control of the Liquidator, which assets consist of a complete plant for the production and distribution of heat and power and for the production of light, situate at the rapidly growing manufacturing town of Berlin, Canada. The plant which was only erected late last year has been in actual operation and the purchaser will reap the benefit of a large number of valuable contracts made by the company for the supply of heat, power and light and will be in time to entertain other valuable contracts now available. The mains for the transmission of heat and power were constructed by American District Steam Company, of Lockport, N. Y., and the plant is likewise equipped in all other respects with the most modern and approved machinery and appliances. Full descriptions and particulars of the real estate and full details, inventories, etc., of the plant, machinery and other assets of the company can be obtained upon application to the Liquidator. An inspection of the plant will be afforded to any intending purchaser at any time. Terms of Sale—25 per cent. cash and balance 25 per cent. in six, twelve and eighteen months respectively, with interest at 7 per cent., and secured to the satisfaction of the Liquidaor. All tenders must be accompanied by a marked cheque, payable to the Liquidator, for 5 per cent. of the amount of tender, which will be returned if tender is not accepted. The highest or any tender will not necessarily be accepted. The other conditions of sale are the standing conditions of sale of the Court as far as applicable. For further particulars and conditions of sale application may be made to the Liquidator or to his solicitors. Osler Wade, Liquidator. W. M. Crane, Esq., Berlin, Canada, and Macdonell, McMaster & Geary, Toronto, Canada, Solicitors for Liquidator. Dated at Toronto 17th July, 1908.

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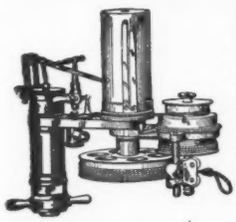

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Don't you know that I can give you a fine up-to-date outfit, new, from $25 00 up, and that I will let you pay a part of it acting as my agent in your spare time?

I will give you a thorough course of indicator instruction with a fine indicator to practice with for $5.00 per mo. Catalog?

Extra ¼ in. Area Cyl. for Ammonia, Gas Engine and high pressure work.

A. C. LIPPINCOTT, Newark, N. J.

YOU

have no idea how simple it is to adjust the Mason Reducing Valve to any desired pressure. Just turn a key. It's as easy as locking a door—*easier* for the key never sticks. **Catalog?**

The Mason Regulator Co., Boston, Mass.

FLINN DIFFERENTIAL STEAM TRAPS

Save their Cost by Increasing Engine Efficiency.

THE EDWARD P. ALLIS COMPANY, Milwaukee, Wis.
[AFTER SELLING OVER 500 FLINN TRAPS.]

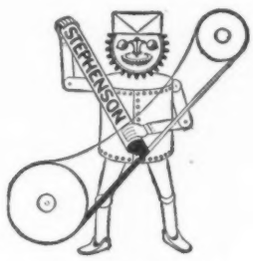
Replying to yours of the 17th inst., we would say that we have used the FLINN DIFFERENTIAL STEAM TRAP for a number of years, practically since its first introduction, and have found it the most general satisfactory trap we have ever used.

Yours, truly,
[Signed] THE EDWARD P. ALLIS COMPANY,
By Irving H. Reynolds.

DESCRIPTIVE CIRCULAR ON REQUEST.

RICHARD J. FLINN, West Roxbury Station, Boston, Mass.

SAMPLES SPEAK LOUDER THAN WORDS



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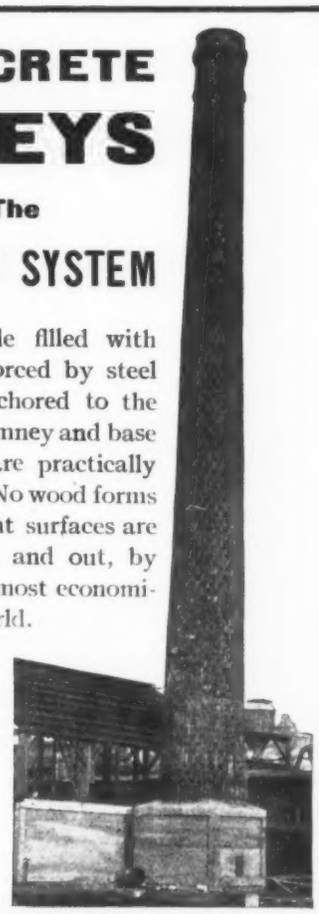

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Mayville Specialty Mfg. Co., Mayville, Wis.
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Garlock Packing Co., Palymra, N. Y.
Harris Oil Co., A. W., Providence, R. I.
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Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.
Stephenson Mfg. Co., Albany, N. Y.
Walton Co., F. S., Phila., Pa.

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Gandy Belting Co., Baltimore, Md.
Garlock Packing Co., Palmyra, N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Johnson Co., Henry, Jersey City N. J.
Laminated Belting Co., New York.
New York Belting & Packing Co., New York.
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Schieren Co., Chas. A., New York.
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Mason Regulator Co., Boston, Mass.

Bending

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Green Fuel Economizer Co., Matteawan, N. Y.

Blowers

De Laval Steam Turbine Co., Trenton, N. J.
Green Fuel Economizer Co., Matteawan, N. Y
Ohio Blower Co., Cleveland, O.
Scully Steel & Iron Co., Chicago, Ill.
Sirocco Engineering Co., New York
Sturtevant Co., B. F., Hyde Park, Mass.
Wing Mfg. Co., L. J., New York.

Blowers, Steam Jet

McClave-Brooks Co., Scranton, Pa.
Monarch Steam Blower Co., Troy, N. Y.
Schutte & Koerting Co., Philadelphia, Pa.

Blow Piping

Ohio Blower Co., Cleveland, O.

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Buckeye Engine Co., Salem, O.

Boiler Cleaners, Automatic

Buckeye Boiler Skimmer Co., Toledo, Ohio.

Boiler Door Arches

McLeod & Henry Co., Troy, N. Y.
Mayville Specialty Mfg. Co., Mayville, Wis.

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National Tube Co., Pittsburg, Pa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

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Fidelity & Casualty Co., New York.

Boiler Insurance

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McLeod & Henry Co., Troy, N. Y.

Boiler Tube Protector

Cruise & Co., Elizabeth, N. J.

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National Tube Co., Pittsburg, Pa.

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Babcock & Wilcox Co., New York.
Beggs & Co., James, New York.
Bigelow Co., New Haven, Conn.
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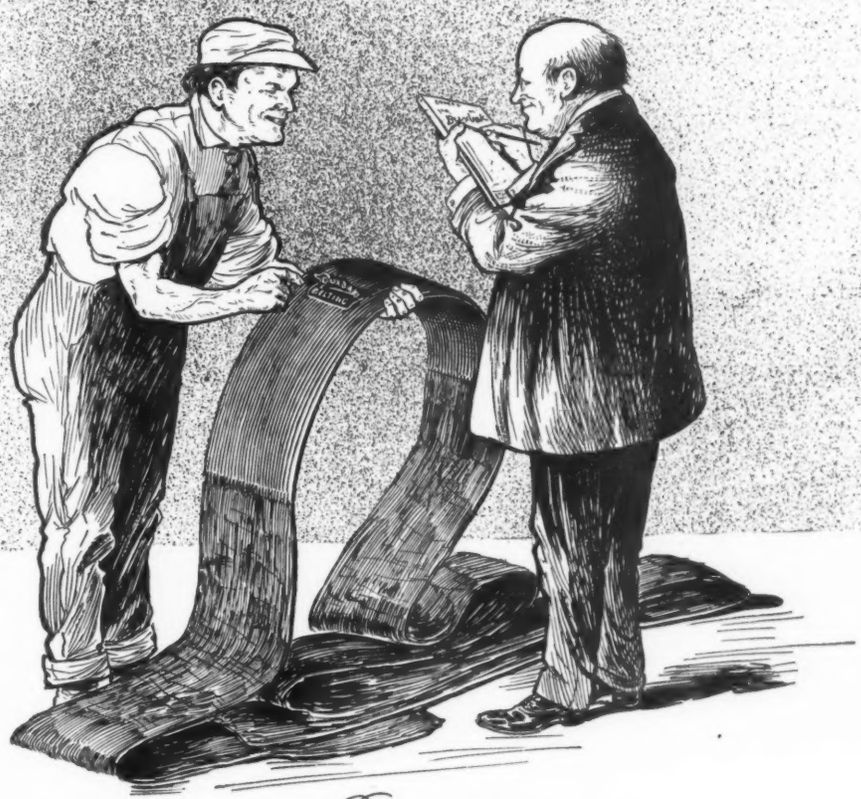

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International Correspond. Schools, Scranton, Pa.

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Scully Steel & Iron Co., Chicago, Ill.

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CO-Two Furnace Co., Syracuse, N. Y.

Brick, Fire Clay
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Salamander Grate Bar Co., New York.

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Cement, Belt
Rhoads & Sons, J. E., Phila., Pa.

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Cement, Rubber
Peerless Rubber Mfg. Co., New York.

Chambers, Air
Hercules Float Works, Springfield, Mass.

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Wiederholdt Construction Co., Chicago, Ill.

Chimneys, Reinforced Concrete
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McCrea & Co., James, Chicago, Ill.

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Liberty Mfg. Co., Pittsburg, Pa.
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Scully Steel & Iron Co., Chicago, Ill.

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See Belt Dressing.

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Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
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Northern Engineering Works, Detroit, Mich.

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Jerguson Mfg. Co., Boston, Mass.
Ohio Brass Co., Mansfield, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Reliance Gauge Column Co., Cleveland, O.
Schæffer & Budenberg Mfg. Co., Foxboro, Mass.
Williams Valve Co., D. T., Cincinnati, Ohio.
Wright Mfg. Co., Detroit, Mich.

Cocks, Steam
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Homestead Valve Mfg. Co., Pittsburg, Pa.
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Lunkenheimer Co., Cincinnati, O.
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Stephenson Mfg. Co., Albany, N. Y.

Compound, Commutator
Dixon Crucible Co., Jos., Jersey City, N. J.
McLennan & Co., K., Chicago, Ill.

Compound, Lubricating
Cook's Sons, Adam, New York.

Compressors, Air
Dean Bros. Steam Pump Works, Indianapolis, Ind.
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Bulkley, Henry W., Orange, N. J.
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Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Prescott Steam Pump Co., F. M., Milwaukee, Wis.
Schutte & Koerting Co., Philadelphia, Pa.
Stewart Heater Co., Buffalo, N. Y.
Warren Steam Pump Co., Warren, Mass.
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Northern Engineering Works, Detroit, Mich.

Crank Pin Turning Machine
Underwood & Co., H. B., Philadelphia, Pa.

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Bigelow Co., New Haven, Conn.

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Ohio Blower Co., Cleveland, O.

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Sturtevant Co., B. F., Hyde Park, Mass.

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Triumph Elec. Co., Cincinnati, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

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Engines, Gas and Gasolene
Ajax Iron Works, Corry, Pa.
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American & British Mfg. Co., Providence, R. I.

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De La Vergne Mach. Co., New York.
Du Bois Iron Works, Du Bois, Pa.
Foos Gas Engine Co., Springfield, Ohio.
Mesta Machine Co., Pittsburg, Pa.
Miller Improved Gas Engine Co., Springfield, O.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Otto Gas Engine Works, Philadelphia, Pa.
Struthers-Wells Co., Warren, Pa.
Westinghouse Mach. Co., Pittsburg, Pa.

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American Diesel Engine Co., New York.
De La Vergne Mach. Co., New York.
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Engines, Steam
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Ball & Wood Co., Elizabethport, N. J.
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Beggs & Co., James, New York.
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Buckeye Engine Co., Salem, O.
Buffalo Forge Co., Buffalo, N. Y.
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De La Vergne Mach. Co., New York.
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Green Fuel Economizer Co., Matteawan, N. Y.
Greenfield, Steam Engine Works, Harrison, N. J.
Griffith & Wedge Co., Zanesville, O.
Griscom-Spencer Co., New York.
Harrisburg Fdry. & Mach. Works, Harrisburg, Pa.
Harris Steam Engine Co., Wm., A., Providence, R. I.
Hewes & Phillips Iron Works, Newark, N. J.
Ide & Son, A. L., Springfield, Ill.
McIntosh, Seymour & Co., Auburn, N. Y.
Mesta Machine Co., Pittsburg, Pa.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Morris Machine Works, Baldwinsville, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Providence Engr. Works, Providence, R. I.
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Ridgway Dynamo & Engine Co., Ridgway, Pa.
Riverside Engine Co., Oil City, Pa.
Rollins Engine Co., Nashua, N. H.
Russell Engine Co., Massillon, O.
St. Louis Iron & Mach. Works, St. Louis, Mo.
Skinner Engine Co., Erie, Pa.
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Vilter Mfg. Co., Milwaukee, Wis.
Watertown Engine Co., Watertown, N. Y.
Westinghouse Mach. Co., Pittsburg, Pa.
York Mfg. Co., York, Pa.

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Direct Separator Co., Syracuse, N. Y.
Gardner Governor & Separator Co., Quincy, Ill.
Hoppes Mfg. Co., Springfield, O.
Loew Mfg. Co., Cleveland, O.
Ohio Blower Co., Cleveland, O.
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Pittsburgh Gage & Supply Co., Pittsburg, Pa.
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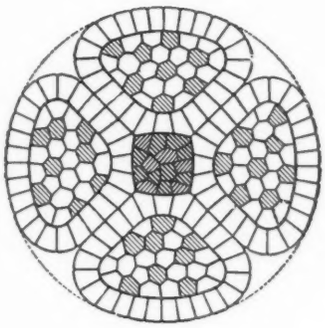
Sims Co., Erie, Pa.

"AMERICAN"

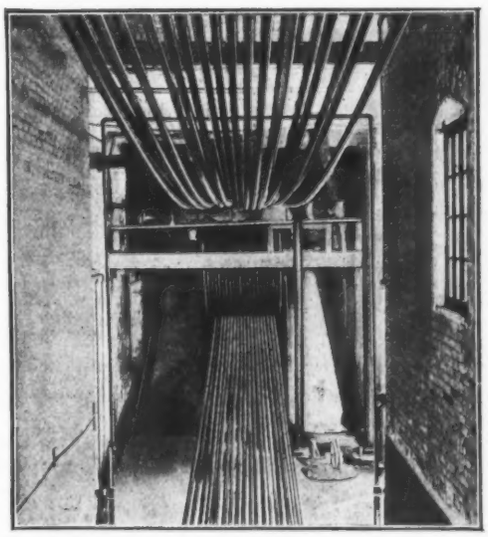


"Like Smooth Rods of Iron"

"American" Transmission Rope in service soon assumes an almost perfectly rounded smooth surface. The graphite lubricant with which the internal yarns and core are saturated, permeates every fibre, facilitating the compression of the strands until the rope becomes smooth and round and presents the greatest area of contact to the sheave groove.

"American" Ropes are designed to turn in their grooves keeping the rope round and smooth and the grooves of the sheaves perfectly true.

If you desire complete information regarding the advantages of rope driving and "American" Transmission Rope, write for a copy of our "Blue Book of Rope Transmission." Copies free.



The American Manufacturing Co.,

128 65 Wall Street, New York City.

TRANSMISSION ROPE

Exhaust Heads—*Continued.*
Sterling Blower & Pipe Mfg. Co., Hartford, Conn.
Sturtevant Co., B. F., Hyde Park, Mass.
Whitlock Coil Pipe Co., Hartford, Conn.
Wright Mfg. Co., Detroit, Mich.

Exhausters, Gas
Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.

Fans, Electric
General Electric Co., Schenectady, N. Y.
Triumph Elec. Co., Cincinnati, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.
Wing Mfg. Co., L. J., New York.

Fans, Exhaust
Anderson Co., V. D., Cleveland, O.
Buffalo Forge Co., Buffalo, N. Y.
Green Fuel Economizer Co., Matteawan, N. Y.
Wing Mfg. Co., L. J., New York.

Feeders, Boiler
American Boiler Economy Co., Philadelphia, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Feeders, Furnace
Ohio Blower Co., Cleveland, O.
Sterling Blower & Pipe Mfg. Co., Hartford, Conn.

Feed Water Heaters and Purifiers
Alberger Condenser Co., New York.
Baragwanath & Son, Wm., Chicago, Ill.
Beggs & Co., James. New York.
Eclipse Feed Water Heater and Purifier Co., Oshkosh, Wis.
Erie Mfg. & Supply Co., Erie, Pa.
Green Fuel Economizer Co., Matteawan, N. Y.
Griscom-Spencer Co., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Kewanee Boiler Co., Kewanee, Ill.
Loew Mfg. Co., Cleveland, O.
Marion Incline Filter and Heater Co., Marion, O.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Murray Iron Works Co., Burlington, Iowa.
National Pipe Bending Co., New Haven, Conn.
Patterson & Co., Frank L., New York.
Robertson & Sons, Jas. L., New York,
Sims Co., Erie, Pa.
Stewart Heater Co., Buffalo, N. Y.
Tudor Boiler Mfg. Co., Cincinnati, O.
Webster & Co., Warren, Camden, N. J.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Filters, Feed Water
Eclipse Feed Water Heater & Purifier Co., Oshkosh, Wis.

Filters, Oil
Beggs & Co., James, New York.
Burt Mfg. Co., Akron, O.
Flower Steam Specialty Co., Walter L., St. Louis, Mo.
Liberty Mfg. Co., Pittsburg, Pa.
Robertson & Sons, Jas. L., New York.
Sims Co., Erie, Pa.
Wright Mfg. Co., Detroit, Mich.

Firebox Blocks
McLeod & Henry Co., Troy, N. Y.

Fittings, Flange
Williams Valve Co., D. T., Cincinnati, Ohio.

Flanges
Ball & Wood Co., Elizabethport, N. J.
Central Station Steam Co., Detroit, Mich.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Jefferson Union Co., Lexington, Mass.

Flanges, Forged Steel
American Spiral Pipe Works, Chicago, Ill.

Flexible Shafts
Stow Mfg. Co., Binghamton, N. Y.

Floats
Anderson Co., V. D., Cleveland, Ohio.
Hercules Float Works, Springfield, Mass.
Reliance Gauge Column Co., Cleveland, Ohio.

Floor Stands
Chapman Valve Mfg. Co., Indian Orchard, Mass.

Flue Cleaners
See Cleaners, Boiler Tube.

Forges
Buffalo Forge Co., Buffalo, N. Y.
Wing Mfg. Co., L. J., New York.

Forgings, Drop
Williams & Co., J. H., Brooklyn, N. Y.

Forgings, Iron and Steel
Griscom-Spencer Co., New York.

Furnaces, Annealing
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Forging
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Hardening
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Melting
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Smokeless
McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Wilkinson Mfg. Co., Bridgeport, Pa.

Furnaces, Tempering
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnace Tile
CO-Two Furnace Co., Syracuse, N. Y.

Gaskets
American Goetze Gasket & Packing Co., New York.
Carey Co., Philip, Cincinnati, O.
Detroit Leather Specialty Co., Detroit, Mich.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Keeler Co., E., Williamsport, Pa.
Mechanical Rubber Co., Cleveland, O.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Wilcox Mfg. Co., E. A., Chicago, Ill.

Gaskets, Copper
American Goetze Gasket & Packing Co., New York.
Central Station Steam Co., Detroit, Mich.

Gaskets, Leather
Detroit Leather Specialty Co., Detroit, Mich.

Gaskets, Water Gauge
Johnson Co., Henry, Jersey City, N. J.
Morse, R. F., Providence, R. I.

Gauge Glasses
Garlock Packing Co., Palmyra, N. Y,
Johnson Co., Henry, Jersey City. N. J.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.
Sterling Lubricator Co., Rochester, N. Y.
Webster & Co., Warren, Camden, N. J.

Gauge Testing Outfit
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.

Gauges, Ammonia
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.

Gauges, Draft
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.

Gauges, Pressure
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.
Webster & Co., Warren, Camden, N. J.
Williams Valve Co., D. T., Cincinnati, Ohio.

Gauges, Recording
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Ohio Injector Co., Wadsworth, Ohio.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Gauges, Vacuum
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Gauges, Water
Greene, Tweed & Co., New York.
Huyette Co., Paul B., Philadelphia, Pa.
Jerguson Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Ohio Brass Co., Mansfield Ohio.
Reliable Water Gauge Co., St. Louis, Mo.
Reliance Gauge Column Co., Cleveland, O.
Safety Equipment Mfg. Co., Chicago, Ill.
Wright Mfg. Co., Detroit, Mich.

Gears
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
New Process Raw Hide Co., Syracuse, N. Y.

Generating Sets
American Engine Co., Bound Brook, N. J.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincinnati, Ohio.

Governors, Inertia
Ide & Son, A. L., Springfield, Ill.

Governors, Pump
American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Davis Co., John, Chicago, Ill.
Fisher Governor Co., Marshalltown, Iowa.
Gardner Governor & Separator Co., Quincy, Ill.
Mason Regulator Co., Boston, Mass.
Safety Equipment Mfg. Co., Chicago, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.
Webster & Co., Warren, Camden, N. J.

Graphite
Garlock Packing Co., Palmyra, N. Y.
Johnson Co., Henry, Jersey City, N. J.

Grates, Chain Traveling
Green Engineering Co., Chicago, Ill.

Grates, Clinker Cutting
McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.

Grates, Dumping
Beggs & Co., James, New York.
Martin Grate Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.
Thacher & Co., George H., Albany, N. Y.

Grates, Shaking
McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.
Robertson & Sons, Jas. L., New York.
Salamander Grate Bar Co., New York.
Thacher & Co., George H., Albany, N. Y.

Grates, Shaking & Dumping
McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.

Grates, Stationary
Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.

Grease
Cook's Sons, Adam, New York.
Dixon Crucible Co., Jos., Jersey City, N. J.
Harris Oil Co., A. W., Providence, R. I.
Kellogg & Co., E. H., New York.
Keystone Lubricating Co., Philadelphia, Pa.
N. Y. & N. J. Lubricant Co., New York.

Grease Extractors
Beggs & Co., James, New York.
Griscom-Spencer Co., New York.
Hussey, McCann & Co., New York.

Heaters, Feed Water
See Feed Water Heaters and Purifiers.

Heating and Ventilating System
Buffalo Forge Co., Buffalo, N. Y.
Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.
Sturtevant Co., B. F., Hyde Park, Mass.
Webster & Co., Warren, Camden, N. J.
Wing Mfg. Co., L. J., New York.

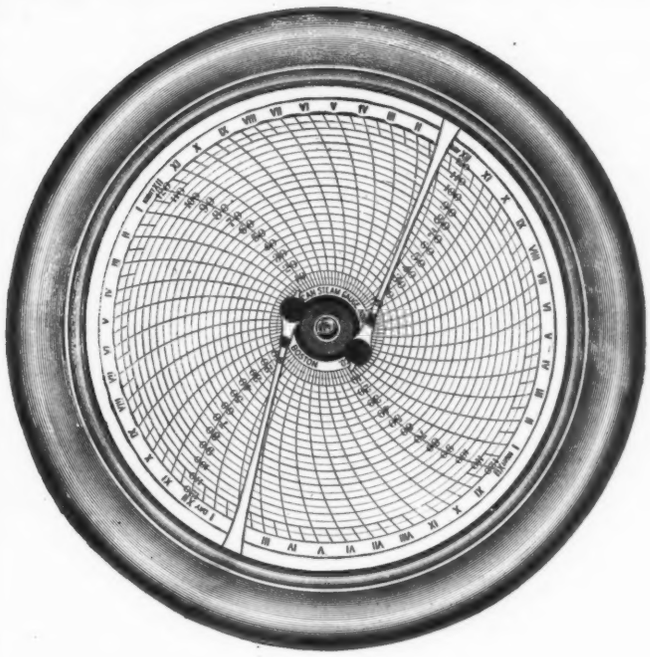
Hoists
Northern Engineering Works, Detroit, Mich.

Hose
Bowers Rubber Works, San Francisco, Cal.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Lagonda Mfg. Co., Springfield, O.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
Myers & Bro., F. E., Ashland, O.
New York Belting & Packing Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa.

Hose, Air
Diamond Rubber Co., Akron, Ohio.
Restein Co., Clement, Philadelphia, Pa.

Hose, Oil
Diamond Rubber Co., Akron, Ohio.
Restein Co., Clement, Philadelphia, Pa.

Hose, Steam
Diamond Rubber Co., Akron, Ohio.
Restein Co., Clement, Philadelphia, Pa.



TWO RECORDING GAUGES IN ONE!

THE AMERICAN DUPLEX RECORDING GAUGE

Combines *two recording gauges in one* and makes it possible to record *two* entirely different pressures on one chart, as each recording arm is connected with a *separate* spring and acts *independently of the other.*

The chart makes *one-half* of a complete revolution in *24 hours.*

The two pressures are recorded on opposite sides of the chart and do not conflict with each other.

Write for Circular 50-CD.

If your jobber does not carry "The American" and will not procure them for you, we will ship to you direct from our factory.

American Steam Gauge & Valve Mfg. Co.

208-220 Camden Street, Boston, Mass.

New York, 26 Cortlandt St. **Atlanta, 835 Equitable Bldg.** **Chicago, 7-9 So. Jefferson St.**

Pittsburg, Frick Building Annex. **San Francisco, 247 Pine Street.**

Montreal, 444 St. James Street. **Los Angeles, 213 So. Los Angeles Street.**

Hose, Water
Diamond Rubber Co., Akron, Ohio.
Restein Co., Clement, Philadelphia, Pa.

Indicators, Gas Engine
American Steam Gauge & Valve Mfg. Co., Boston, Mass.

Indicators, Speed
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.
Starrett Co., L. S., Athol, Mass.

Indicators, Steam Engine
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty & Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.
Star Brass Mfg. Co., Boston, Mass.
Trill Indicator Co., Corry, Pa.

Injectors
American Injector Co., Detroit, Mich.
Desmond-Stephan Mfg. Co., Urbana, O.
Detroit Lubricator Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.
Randle Machinery Co., Cincinnati, Ohio.
Robertson & Sons, Jas. L., New York.
Schutte & Koerting Co., Philadelphia, Pa.
Sherwood Mfg. Co., Buffalo, N. Y.

Joints, Expansion
Alberger Condenser Co., New York.
Central Station Steam Co., Detroit, Mich.
Webster & Co., Warren, Camden, N. J.

Joints, Pipe
McCrea & Co., James, Chicago, Ill.

Joints, Rubber
Diamond Rubber Co., Akron, Ohio.

Lamps, Arc
General Elec. Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Lamps, Incandescent
General Elec. Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Lathes, Foot Power
Barnes Co., W. F. & John, Rockford, Ill.

Leather, Lace
Rhoads & Sons, J. E., Phila., Pa.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Lubricants
Cook's Sons, Adam, New York.
N. Y. & N. J. Lubricant Co., New York.

Lubricating and Oiling Devices
Lunkenheimer Co., Cincinnati, O.
Nugent & Co., W. W., Chicago, Ill.

Lubricators
Cook's Sons, Adam, New York.
Detroit Lubricator Co., Detroit, Mich.
Greene, Tweed & Co., New York.
Griscom-Spencer Co., New York
Lunkenheimer Co., Cincinnati, O.
Manzel Bros. Co., Buffalo, N. Y.
Michigan Lubricator Co., Detroit, Mich.
Ohio Injector Co., Wadsworth, O.
Powell Co., Wm., Cincinnati, O.
Robertson & Sons, Jas. L., New York.
Sherwood Mfg. Co., Buffalo, N. Y.
Sight Feed Oil Pump Co., Milwaukee, Wis.
Stephenson Mfg. Co., Albany, N. Y.
Sterling Lubricator Co., Rochester, N. Y.

Machines, Ice
Vilter Mfg. Co., Milwaukee, Wis.

Machines, Pipe Cutting and Threading
Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Crane Co., Chicago, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Toledo Pipe Threading Machine Co., Toledo, Ohio.
Trimont Mfg. Co., Roxbury, Mass.

Machinery, Second Hand
Hewes & Phillips Iron Works, Newark, N. J.
Randle Machinery Co., Cincinnati, Ohio.
Wickes Bros., Saginaw, Mich.

Machinists, General
American & British Mfg. Co., Providence, R. I.
Bruce-Meriam-Abbott Co., Cleveland, O.
Mathews, Hugh, Kansas City, Mo.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Providence Engineering Works, Providence, R. I.

Mats & Matting, Rubber
Diamond Rubber Co., Akron, Ohio.
Home Rubber Co., Trenton, N. J.
Mercer Rubber Co., Hamilton Square, N. J.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.

Mechanical Draft
Buffalo Forge Co., Buffalo, N. Y.
Green Fuel Economizer Co., Matteawan, N. Y.
Sturtevant Co., B. F., Hyde Park, Mass
Wing Mfg. Co., L. J., New York.

Metal, Anti-Friction
Allan & Son, A., New York.

Metals, Bearing
Allan & Son, A., New York.
Phosphor Bronze Smelting Co., Ltd., Philadelphia, Pa.

Metal Polish
Hoffman, Geo. W., Indianapolis, Ind.

Meters, Steam
St. John, G. C., New York.

Micrometers
Starrett Co., L. S., Athol, Mass.

Milling Machines, Portable
Underwood & Co., H. B., Philadelphia, Pa.

Mill Supplies
Quaker City Rubber Co., Philadelphia, Pa.

Mining and Smelting Machinery
Moore & Co., Chas. C., San Francisco, Cal.

Motors and Dynamos
American Engine Co., Bound Brook, N. J.
Clark Bros. Co., Belmont, N. Y.
General Elec. Co., Schenectady, N.Y.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Stow Mfg. Co., Binghamton, N. Y.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Elec. Co., Cincinnati, Ohio.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Motors, Water
Lagonda Mfg. Co., Springfield, O.

Nipples
National Tube Co., Pittsburg, Pa

Oil and Grease Cups
American Injector Co., Detroit, Mich.
Cook's Sons, Adam, New York.
Griscom-Spencer Co., New York.
Keystone Lubricating Co., Philadelphia, Pa.
Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.
Powell Co., Wm., Cincinnati, O.

Oil and Grease Cups—*Cont.*
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.
Sherwood Mfg. Co., Buffalo, N. Y.
Williams Valve Co., D. T., Cincinnati, Ohio.

Oil Burners
Hammel Oil Burner Co., Los Angeles, Cal.

Oil Dash Pots
Lammert & Mann, Chicago, Ill.

Oil Reservoirs
Burt Mfg. Co., Akron, O.

Oilers, Crank Pin
Penberthy Injector Co., Detroit, Mich.

Oiling Systems
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Oils
Cook's Sons, Adam, New York.
Dearborn Drug & Chemical Wks., Chicago, Ill.
Harris Oil Co., A. W., Providence, R. I.
Kellogg & Co., E. H., New York.
New York & New Jersey Lubricant Co., New York.

Oils, Non Fluid
N. Y. & N. J. Lubricant Co., New York.

Packing, Asbestos
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
Restein Co., Clement, Philadelphia, Pa.

Packing, Flange
Carey Co., Philip, Cincinnati, O.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa.
Robertson & Sons, Jas. L., New York.
Smooth-On Mfg. Co., Jersey City, N. J.

Packing, Hydraulic
Brandt, Randolph, New York.
Detroit Leather Specialty Co., Detroit, Mich.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Schieren Co., Chas. A., New York.

Packing, Metallic
American Huhn Metallic Packing Co., New York.
Bridgeport Metallic Packing Co., Bridgeport, Conn.
Garlock Packing Co., Palmyra, N. Y.
Houchin-Aiken Co., Brooklyn, N.Y.
Johnson Co., Henry, Jersey City, N. J.
Mercer Rubber Co., Hamilton Square, N. J.
Tripp Metallic Packing Co., Boston, Mass.

Packing, Piston
American Steam Packing Co., Boston, Mass.
Bowers Rubber Works, San Francisco, Cal.
Carey Co., Philip, Cincinnati, O.

Packing, Piston—*Continued.*
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Underwood & Co., H. B., Philadelphia, Pa.

Packing, Pneumatic
Detroit Leather Specialty Co., Detroit, Mich.
Mercer Rubber Co., Hamilton Square, N. J.

Packing, Pump Valve
Diamond Rubber Co., Akron, Ohio.
Home Rubber Co., Trenton, N. J.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Packing, Rod
American Huhn Metallic Packing Co., New York.
Bowers Rubber Co., San Francisco, Cal.
Brandt, Randolph, New York.
Bridgeport Metallic Packing Co., Bridgeport, Conn.
Carey Co., Philip, Cincinnati, O.
Diamond Rubber Co., Akron, Ohio.
Flower Steam Specialty Co., Walter L., St. Louis, Mo.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Sayen, Osgood, Philadelphia, Pa.
Steel Mill Packing Co., Detroit, Mich.

Packing, Valve Stem
Diamond Rubber Co., Akron, Ohio.
Home Rubber Co., Trenton, N. J.
Mechanical Rubber Co., Cleveland, Ohio.
Mercer Rubber Co., Hamilton Square, N. J.
Quaker City Rubber Co., Philadelphia, Pa.

Pipe
Ball & Wood Co., Elizabethport, N. J.
Central Station Steam Co., Detroit, Mich.

Pipe, Riveted Steel
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.

Pipe, Spiral
American Spiral Pipe Works, Chicago, Ill.

Pipe, Wrought
National Tube Co., Pittsburg, Pa.

Pipe Bending
Ball & Wood Co., Elizabethport, N. J.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Pipe Coils, Brass, Iron and Copper
McCrea & Co., James, Chicago, Ill.
National Pipe Bending Co., New Haven, Conn.
Whitlock Coil Pipe Co., Hartford, Conn.

Websterizing

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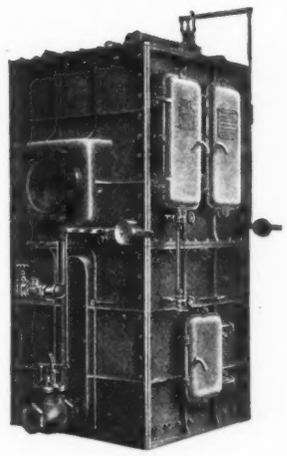


No. 1.

Makers of good boilers and builders of good engines can guarantee you high steam and power economy only *when the conditions are right.*

If the feed water contains injurious properties that get into the boiler all the guarantees in the world can't make that boiler efficient or economical.

If there's wet steam in the supply pipe no engine is safe or economical.

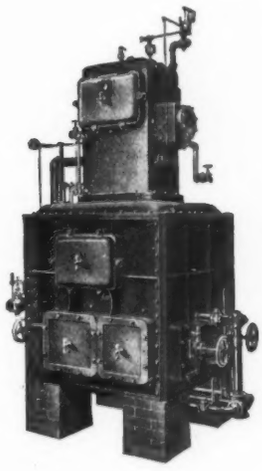
It's obvious that the "conditions"—all of them (the above are only two of many)—must be right before satisfactory results can be obtained.

Therein lies the universal value of Webster Appliances. They are a line of Steam Specialties designed to make all power plant "conditions" right—to make the boiler, the engine, the whole plant operate with highest efficiency and economy.

First among these devices are the Webster Feed Water Heaters, Purifiers and Filters. Cut No. 1 is the regular type; Cut No. 2 shows the Chemical Purifier.

These Heaters are made in a number of different types and sizes to suit various individual requirements. No one Heater can possibly be best for all cases, and our selling plan includes a careful diagnosis of the special conditions existing at your plant.

Our expert engineers then prescribe the proper Heater and we positively guarantee it to perform its work with utmost satisfaction. We have no desire to place a Webster Feed Water Heater where it cannot do its work perfectly.



No. 2.

Once you have installed a Webster Heater, however, you will find that it rights the "conditions" in your water supply and sends the water into the boilers at the highest possible temperature, using just enough exhaust steam to accomplish that end—and not acting as a thoroughfare for all the exhaust.

Any of the users of the 2,250,000 horse power now operating will tell you how well it pays to "Websterize."

In the utilization of exhaust steam the Webster Oil Separator, shown in cut No. 2, has played an important part for 20 years.

In its design and construction are embodied principles which long experience in exhaust steam heating has proved to be necessary.

One of these devices is installed as a part of every Webster Heater, nearly 4000 of them being used for that purpose, rendering the condensation of the exhaust steam fit for use as boiler feed.

Many thousand other separators are in use in connection with the Webster System of Steam Circulation, which is known throughout the country as the most efficient method of utilizing exhaust steam for heating. Our long experience in that line of work has given us the knowledge of what an Oil Separator should do, and how it should be done.

We build Steam Separators, too, in many styles, and for many special purposes.

Write for Heater booklet, 12-F, Chemical Purifier booklet, 12-C, or Separator booklet, 12-S, which tell more about Webster appliances.

No. 3.

6

Warren Webster & Co., Camden, N.J.

Pipe Fittings

Crane Co., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.
McCrea & Co., James, Chicago, Ill.
National Tube Co., Pittsburg, Pa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburg Valve & Fittings Co., Pittsburg, Pa.
Pittsburg Valve, Foundry and Construction Co., Pittsburg, Pa.
Trimont Mfg. Co., Roxbury, Mass.

Pipe Joints, Compound

Dixon Crucible Co., Jos., Jersey City, N. J.

Planimeters

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lippincott Steam Specialty & Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.

Plumbago

Dixon Crucible Co., Jos., Jersey City, N. J.

Power Plant Supplies

Safety Equipment Mfg. Co., Chicago, Ill.

Preventers, Smoke

Climax Smoke Preventer Co., Boston, Mass.

Producers, Gas

Amsler, W. O. and Davis, A. C., Pittsburg, Pa.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Power & Mining Mach. Co., Cudahy, Wis.

Publishers

Hill Publishing Co., New York.
International Corresp. Schools, Scranton, Pa.

Pulleys

American Pulley Co., Phila., Pa.
Dodge Mfg. Co., Mishawaka, Ind.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Philips Pressed Steel Pulley Works, Philadelphia, Pa.

Pulleys, Clutch

Williams Foundry & Mach. Co., Akron, Ohio.

Pumps, Air

Dean Bros. Steam Pump Works, Indianapolis, Ind.
Du Bois Iron Works, Du Bois, Pa.
Goulds Mfg. Co., Seneca Falls, N. Y.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Prescott Steam Pump Co., F. M., Milwaukee, Wis.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Boiler Feed

Kewanee Boiler Co., Kewanee, Ill.

Pumps, Centrifugal

Alberger Condenser Co., New York.
Morris Machine Works, Baldwinsville, N. Y.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Electric

Dean Bros. Steam Pump Works, Indianapolis, Ind.
Du Bois Iron Works, Du Bois, Pa.
Goulds Mfg. Co., Seneca Falls, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Hydraulic

Goulds Mfg. Co., Seneca Falls, N. Y.

Pumps, Oil

Burt Mfg. Co., Akron, O.
Detroit Lubricator Co., Detroit, Mich.
Du Bois Iron Works, Du Bois, Pa.
Goulds Mfg. Co., Seneca Falls, N. Y.
Lunkenheimer Co., Cincinnati, O.
Manzel Bros. Co., Buffalo, N. Y.
Sherwood Mfg. Co., Buffalo, N. Y.
Sight Feed Oil Pump Co., Milwaukee, Wis.

Pumps, Power

Deming Co., Salem, Ohio.
Myers & Bro., F. E., Ashland, O.
Patterson & Co., Frank L., New York.
Stewart Heater Co., Buffalo, N. Y.
Whitlock Coil Pipe Co., Hartford, Conn.

Pumps, Steam

Buffalo Steam Pump Co., Buffalo, N. Y.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Du Bois Iron Works, Du Bois, Pa.
Gardner Governor and Separator Co., Quincy, Ill.
Mason Regulator Co., Boston, Mass.
Minneapolis Steel & Machry. Co., Minneapolis, Minn.
Murray Iron Works Co., Burlington, Iowa.
Prescott Steam Pump Co., F. M., Milwaukee, Wis.
Safety Equipment Mfg. Co., Chicago, Ill.
Warren Steam Pump Co., Warren, Mass.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Triplex

Minneapolis Steel & Mchry. Co., Minneapolis, Minn.

Pumps, Turbine

Alberger Condenser Co., New York.

Pumps, Vacuum

Alberger Condenser Co., New York.
Prescott Steam Pump Co., F. M., Milwaukee, Wis.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Rams, Steam

Penberthy Injector Co., Detroit, Mich.

Reducing Wheels

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Robertson & Sons, Jas. L., New York.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.
Trill Indicator Co., Corry, Pa.

Refrigerating Machinery

De La Vergne Machine Co., New York.
Vilter Mfg. Co., Milwaukee, Wis.
Vogt Machine Co., Henry, Louisville, Ky.
York Mfg. Co., York, Pa.

Regulators, Damper

Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
Mason Regulator Co., Boston, Mass.
Robertson & Sons, Jas. L., New York.
Strong, Carlisle & Hammond Co., Cleveland, O.

Regulators, Feed Water

American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Jerguson Mfg. Co., Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Mason Regulator Co., Boston, Mass.
Murray Automatic Boiler Feed Co., Detroit, Mich.
Safety Equipment Mfg. Co., Chicago, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Philadelphia, Pa.

Regulators, Pressure

American Boiler Economy Co., Philadelphia, Pa.
American District Steam Co., Lockport, N. Y.
Davis Regulator Co., G. M., Chicago, Ill.
Fisher Governor Co., Marshalltown, Iowa.
Lagonda Mfg. Co., Springfield, O.
Mason Regulator Co., Boston, Mass.
Ohio Brass Co., Mansfield, Ohio.
Strong, Carlisle & Hammond Co., Cleveland, O.

Regulators, Rheostat

Mason Regulator Co., Boston, Mass.

Repairs, Engine and Pump

Underwood & Co., H. B., Philadelphia, Pa.

Reseating Machines, Flue Cap

Lagonda Mfg. Co., Springfield, O.
Leavitt Machine Co., Orange, Mass.
Liberty Mfg. Co., Pittsburg, Pa.

Revolution Counters

American Steam Gauge & Valve Mfg. Co., Boston, Mass.

Rope Dressing

Cling Surface Co., Buffalo, N. Y.

Rope Transmission

American Mfg. Co., New York.
Dodge Mfg. Co., Mishawaka, Ind.
Plymouth Cordage Co., No. Plymouth, Mass.

Rubber Goods

Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Griscom-Spencer Co., New York.
Home Rubber Co., Trenton, N. J.
Mechanical Rubber Co., Cleveland, Ohio.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Resten Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Philadelphia, Pa.

Schools, Correspondence

International Correspond. Schools, Scranton, Pa.

Separators, Ammonia

Harrison Safety Boiler Works, Philadelphia, Pa.

Separators, Oil

Austin Separator Co., Detroit, Mich.
Baragwanath & Son, Wm., Chicago, Ill.
Direct Separator Co., Syracuse, N. Y.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hershey Foundry & Machine Co., Manheim, Pa.
Hoppes Mfg. Co., Springfield, O.
Hussey, McCann & Co., New York.
Liberty Mfg. Co., Pittsburg, Pa.
Loew Mfg. Co., Cleveland, O.
Marion Incline Filter & Heater Co., Marion, Ohio.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Ohio Blower Co., Cleveland, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Robertson & Sons, Jas. L., New York.
Webster & Co., Warren, Camden, N. J.
Wright Mfg. Co., Detroit, Mich.

Separators, Oil and Water

Harrison Safety Boiler Works, Philadelphia, Pa.
Keyes & Son, F. E., New York.

Separators, Steam

Austin Separator Co., Detroit, Mich.
Baragwanath & Son, Wm., Chicago, Ill.
d'Este & Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Gardner Governor and Separator Co., Quincy, Ill.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hershey Foundry & Machine Co., Manheim, Pa.
Hoppes Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Loew Mfg. Co., Cleveland, O.
Marion Incline Filter & Heater Co., Marion, Ohio.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Ohio Blower Co., Cleveland, O.
Patterson & Co., Frank L., New York.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Robertson & Sons, Jas. L., New York.

Separators, Steam—*Continued*

Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.
Sims Co., Erie, Pa.
Webster & Co., Warren, Camden, N. J.
Whitlock Coil Pipe Co., Hartford, Conn.
Wright Mfg. Co., Detroit, Mich.

Shafts, Counter

Myers & Bro., F. E., Ashland, O.

Sheaves

Minneapolis Steel & Mchy. Co., Minneapolis, Minn.

Skimmers, Boiler

Buckeye Boiler Skimmer Co., Toledo, Ohio.

Skylights

Burt Mfg. Co., Akron, O.

Smoke Preventers

Climax Smoke Preventer Co., Boston, Mass.

Spray Nozzles

Schutte & Koerting Co., Philadelphia, Pa.

Stacks, Steel

Bigelow Co., New Haven, Conn.
Keeler Co., E., Williamsport, Pa.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Morrin Climax Boiler Co., Brooklyn, N. Y.

Steam Heating Supplies

Beggs & Co., James, New York.
Crosby Steam Gage & Valve Co., Boston, Mass.
Dunham Co., C. A., Marshalltown, Iowa.
Eastwood Wire Mfg. Co., Bellville, N. J.
Fisher Governor Co., Marshalltown, Iowa.
Nason Mfg. Co., New York.
New York Belting & Packing Co., New York.
Ohio Brass Co., Mansfield, O.
Peerless Rubber Mfg. Co., New York.
Reliance Gauge Column Co., Cleveland, O.
Strong, Carlisle & Hammond Co., Cleveland, O.
Wright Mfg. Co., Detroit, Mich.

Steam Specialties

Crane Co., Chicago, Ill.
Ohio Brass Co., Mansfield, Ohio.

Stocks, Die

Armstrong Mfg. Co., Bridgeport, Conn.
Toledo Pipe Threading Machine Co., Toledo, O.

Stokers, Mechanical

Detroit Stoker and Foundry Co., Detroit, Mich.
Green Engineering Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Westinghouse Mach. Co., Pittsburg, Pa.
Wilkinson Mfg. Co., Bridgeport, Pa.

Strainers

American Injector Co., Detroit, Mich.
Liberty Mfg. Co., Pittsburg, Pa.
Webster & Co., Warren, Camden, N. J.

Superheaters

Babcock & Wilcox Co., New York.
Parker Boiler Co., Philadelphia, Pa.
Power Specialty Co., New York.
Providence Engineering Works, Providence, R. I.

Switchboards

General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Switches, Electric

General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Syphons

National Tube Co., Pittsburg, Pa.
Schutte & Koerting Co., Philadelphia, Pa.

There is a Chief Engineer in this City who has been in charge of a large plant for about thirty years.

In talking over business matters a short time ago, he said:—

"If there is one thing more than another that sets me against a salesman, it is to have him argue with me that a low priced and adulterated article will save me money.

"Now the most important thing to me is safety. One shut-down of my plant for ten minutes due to the use of a bad article would nearly put me out of business.

"I have used LORD'S CHEMICALS for about twenty-five years. I know that my boilers are safe when LORD'S CHEMICALS are in them, and I have learned that I pay less per year for LORD'S CHEMICALS than other engineers pay for ready-made liquid preparations which contain a great quantity of water."

Send for our Pamphlet entitled: "Boiler Scale, Its Formation and Removal."

George W. Lord Co.,
2238-2250 North 9th St.,
Philadelphia, Penna.

Tanks
Bigelow Co., New Haven, Conn.
Griscom-Spencer Co., New York.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
New Bedford Boiler & Mach. Co., New Bedford, Mass.

Taps and Dies
Toledo Pipe Threading Machine Co., Toledo, O.

Thermometers
Bristol Co., Waterbury, Conn.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.

Tools
Mound Tool & Scraper Co., St. Louis, Mo.
Trimont Mfg. Co., Roxbury, Mass.

Transformers and Converters
General Elec. Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Transmission
American Mfg. Co., New York.
American Pulley Co., Philadelphia, Pa.
Dodge Mfg. Co., Mishawaka, Ind.
Gandy Belting Co., Baltimore, Md.
Jeffrey Mfg. Co., Columbus, O.
Mesta Machine Co., Pittsburg, Pa.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Plymouth Cordage Co., No. Plymouth, Mass.
Rhoads & Sons, J. E., Philadelphia, Pa.

Traps
American District Steam Co., Lockport, N. Y.
Anderson Co., V. D., Cleveland, O.
Central Station Steam Co., Detroit, Mich.
Davis Co., John, Chicago, Ill.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Dunham Co., C. A., Marshalltown, Iowa.
Flinn, Richard J., W. Roxbury Station, Boston, Mass.
Golden-Anderson Valve Specialty Co., Pittsburg, Pa.
Harrison Safety Boiler Works, Philadelphia, Pa.
McCrea & Co., James, Chicago, Ill.
Morehead Mfg. Co., Detroit, Mich.
Nason Mfg. Co., New York.
Ohio Blower Co., Cleveland, O.
Platt & Co., John, New York.
Reliance Gauge Column Co., Cleveland, O.
Safety Equipment Mfg. Co., Chicago, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Philadelphia, Pa.
Webster & Co., Warren, Camden, N. J.
Williams Valve Co., D. T., Cincinnati, Ohio.
Wright Mfg. Co., Detroit, Mich.

Tube Cleaners
See Cleaners (Boiler Tube).

Tube Cutters
Lagonda Mfg. Co., Detroit, Mich.

Tubing
National Tube Co., Pittsburg, Pa.

Tubing, Metallic
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.

Turbines, Steam
De Laval Steam Turbine Co., Trenton, N. J.
General Elec. Co., Schenectady, N. Y.
Kerr Turbine Co., Wellsville, N. Y.
Westinghouse Machine Co., Pittsburg, Pa.
Wing Mfg. Co., L. J., New York.

Unions
Bard Union Co., Norwich, Conn.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Dart Mfg. Co., E. M., Providence, R. I.
Jefferson Union Co., Lexington, Mass.
National Tube Co., Pittsburg, Pa.
Ohio Brass Co., Mansfield, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves & Washers, Leather
Rhoads & Sons, J. E., Phila., Pa.
Schieren Co., Chas. A., New York.

Valve Balls
Diamond Rubber Co., Akron, Ohio.

Valve Discs
Allan & Son, A., New York.
Diamond Rubber Co., Akron, Ohio.
Mechanical Rubber Co., Cleveland, O.

Valve Reseating Machine
Leavitt Machine Co., Orange, Mass.

Valve Seat Planing Machine
Underwood & Co., H. B., Philadelphia, Pa.

Valves
Crane Co., Chicago, Ill.
Liberty Mfg. Co., Pittsburg, Pa.
National Tube Co., Pittsburg, Pa.
New Bedford Boiler & Mach. Co., New Bedford, Mass.
Ohio Brass Co., Mansfield, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Ammonia
York Mfg. Co., York, Pa.

Valves, Angle
New Bedford Boiler & Mach. Co., New Bedford, Mass.

Valves, Automatic
Golden-Anderson Valve Specialty Co., Pittsburg, Pa.
Lagonda Mfg. Co., Springfield, O.
Safety Equipment Mfg. Co., Chicago, Ill.
Webster & Co., Warren, Camden, N. J.

Valves, Back Pressure
Schutte & Koerting Co., Philadelphia, Pa.
Walch & Wyeth, Chicago, Ill.

Valves, Balance
Mason Regulator Co., Boston, Mass.

Valves, Blow-off
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Homestead Valve Mfg. Co., Pittsburg, Pa.
Huxley Valve Co., Buffalo, N. Y.
Liberty Mfg. Co., Pittsburg, Pa.
Ludlow Valve Mfg. Co., Troy, N. Y.
Lunkenheimer Co., Cincinnati, O.
Pittsburg Gage & Supply Co., Pittsburg, Pa.

Valves, Boiler Stop
Davis Regulator Co., G. M., Chicago, Ill.
Golden-Anderson Valve Specialty Co., Pittsburg, Pa.
New Bedford Boiler & Mach. Co., New Bedford, Mass.

Valves, By-Pass
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Mason Regulator Co., Boston, Mass.

Valves, Check
Greene, Tweed & Co., New York.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Ludlow Valve Mfg. Co., Troy, N. Y.
Nelson Valve Co., Philadelphia, Pa.
Pittsburg Valve and Fittings Co., Pittsburg, Pa.
Walch & Wyeth, Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Cylinder Relief
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.

Valves, Drain
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Electric
Nelson Valve Co., Philadelphia, Pa.

Valves, Electrically Operated Trip
Schutte & Koerting Co., Philadelphia, Pa.

Valves, Exhaust
Nelson Valve Co., Philadelphia, Pa.

Valves, Exhaust Relief
Alberger Condenser Co., New York.
Davis Co., John, Chicago, Ill.
Walch & Wyeth, Chicago, Ill.

Valves, Foot
New Bedford Boiler & Mach. Co., New Bedford, Mass.

Valves, Free Exhaust
Schutte & Koerting Co., Philadelphia, Pa.

Valves, Gas
Nelson Valve Co., Philadelphia, Pa.

Valves, Gate
Central Station Steam Co., Detroit, Mich.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Greene, Tweed & Co., New York.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Ludlow Valve Mfg. Co., Troy, N. Y.
Nelson Valve Co., Philadelphia, Pa.
Ohio Brass Co., Mansfield, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Pittsburgh Valve & Fittings Co., Pittsburg, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburg, Pa.
Walch & Wyeth, Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Globe
Detroit Lubricator Co., Detroit, Mich.
Eastwood Wire Mfg. Co., Belleville, N. J.
Ludlow Valve Mfg. Co., Troy, N. Y.
Lunkenheimer Co., Cincinnati, O.
Nelson Valve Co., Philadelphia, Pa.
New Bedford Boiler & Mach. Co., New Bedford, Mass.
Ohio Brass Co., Mansfield, O.
Pittsburgh Valve & Fittings Co., Pittsburg, Pa.
Pittsburgh Valve, Fdry. and Construction Co., Pittsburg, Pa.
Powell Co., Wm., Cincinnati, O.

Valves, Hose Gate
Nelson Valve Co., Philadelphia, Pa.

Valves, Hydraulic
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Nelson Valve Co., Philadelphia, Pa.
Schutte & Koerting Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Incinerator
Nelson Valve Co., Philadelphia, Pa.

Valves, Lever Gate
Nelson Valve Co., Philadelphia, Pa.

Valves, Lever and Throttle
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Mason Regulator Co., Boston, Mass.
Powell Co., Wm., Cincinnati, O.

Valves, Non-return
Golden-Anderson Valve Specialty Co., Pittsburg, Pa.
Walch & Wyeth, Chicago, Ill.

Valves, Pneumatic
Nelson Valve Co., Philadelphia, Pa.

Valves, Pop Safety
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Ashton Valve Co., Boston, Mass.
Kunkle & Co., E. B., Fort Wayne, Ind.
Lunkenheimer Co., Cincinnati, O.
Star Brass Mfg. Co., Boston, Mass.

Valves, Pump
Garlock Packing Co., Palmyra, N. Y.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.

Valves, Railroad
Nelson Valve Co., Philadelphia, Pa.

Valves, Reducing
See Pressure Regulators.

Valves, Regrinding
Nelson Valve Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Regulating
Fisher Governor Co., Marshalltown, Iowa.
Ohio Brass Co., Mansfield, Ohio.

Valves, Safety
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Kunkle & Co., E. B., Fort Wayne, Ind.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburg, Pa.
Walch & Wyeth, Chicago, Ill.

Valves, Safety Gate
Walch & Wyeth, Chicago, Ill.

Valves, Steam
Nelson Valve Co., Philadelphia, Pa.

Valves, Stop Check
Schutte & Koerting Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Superheated Steam
Nelson Valve Co., Philadelphia, Pa.

Valves, Swing Gate
Walch & Wyeth, Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Tank
Nelson Valve Co., Philadelphia, Pa.

Valves, Water
Nelson Valve Co., Philadelphia, Pa.

Valves, Water Relief
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.

Ventilators
Burt Mfg. Co., Akron, O.
Ohio Blower Co., Cleveland, O.
Wing Mfg. Co., L. J., New York.

Vises
Armstrong Mfg. Co., Bridgeport, Conn.

Vulcanizers
Bigelow Co., New Haven, Conn.

Water Columns
Davis Co., John, Chicago, Ill.
Jerguson Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Reliance Gauge Column Co., Cleveland, O.
Robertson & Sons, Jas. L., New York.
Safety Equipment Mfg. Co., Chicago, Ill.
Wright Mfg. Co., Detroit, Mich.

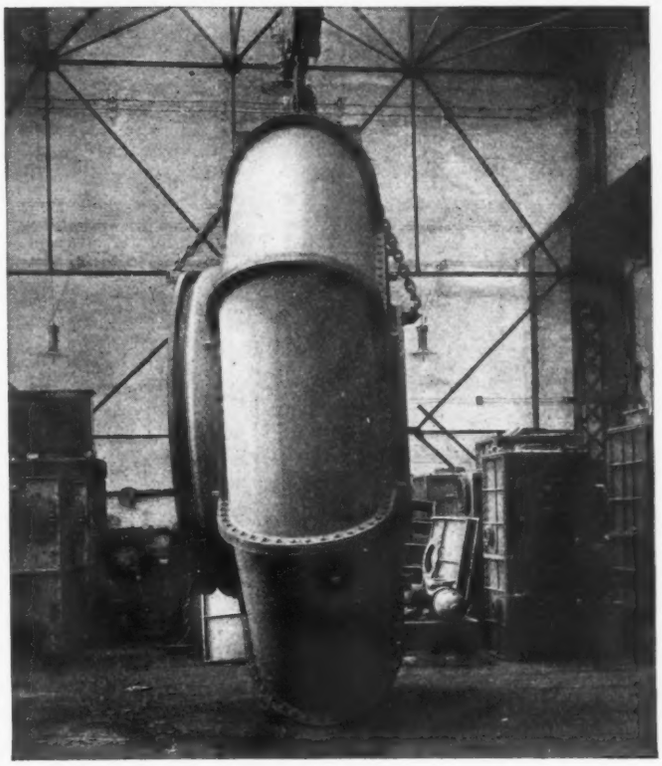
Water Purifiers, Feed
Harrison Safety Boiler Works, Philadelphia, Pa.
Keyes & Son, F. E., New York.

Water Softening Apparatus
Bird-Archer Co., New York.
Dodge Mfg. Co., Mishawaka, Ind.
Harrison Safety Boiler Works, Philadelphia, Pa.
Marion Incline Filter & Heater Co., Marion, O.
Scaife & Sons Co., Wm. B., Pittsburg, Pa.

Whistles
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.

Wrenches
Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Wrenches, Pipe
Armstrong Mfg. Co., Bridgeport, Conn.
Trimont Mfg. Co., Roxbury Mass.
Williams & Co., J. H., Brooklyn, N. Y.



RATHER BIG

But what's the difference—you get just the same good results out of one of our 1½" or 6" Cochrane Oil Separators as you do out of our 90" ones.

The principle is the same in all sizes, but engineers are a bit more particular when buying for large plants.

Besides what our separators will do of themselves, there's the record they are making in something like 10,000,000 H.P. of steam power plants and the experience which we have had in making all these installations,—which experience is right at your service.

COCHRANE SEPARATORS

What is the object of an oil separator? Simply to purify the exhaust steam from cylinder oil, since this steam, which is well worth saving because it is distilled water and because of the heat which it contains, should be put to use, thereby supplanting that much raw water, which may be impure, or which may have to be bought, or which may be scarce. Having the exhaust steam free from oil you keep your radiators, coils, condensers, or even your closed heaters, from fouling up, which fouling up decreases their efficiency and capacity.

You can hardly afford to be without a separator where you have exhaust steam which you can utilize, and the only question is selecting a good one—one which will give you the service and one which will do it satisfactorily. The Cochrane Oil Separators have pleased so many thousands of engineers and steam plant owners that we are certain they would please you. Their record is not approached by that of any other appliance for the same purpose.

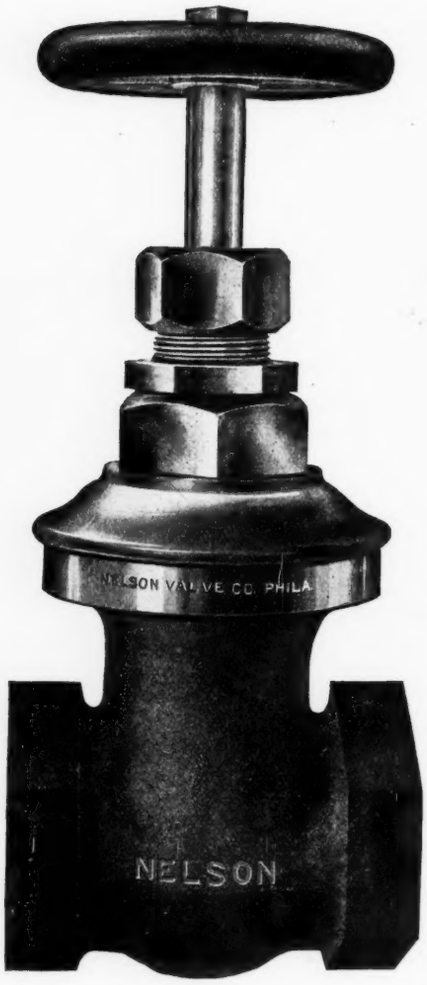
Then there are the Cochrane Heaters, of which you have doubtless heard. Their success has been due in large part to the remarkable efficiency of the Cochrane Oil Separators, one of which is attached to and forms part of each of these heaters. The Cochrane Heaters are not only superior to any form of closed or pressure heaters, because they save more heat and all the exhaust, give purification, are not subject to leakage and last longer, but they are also better than the imitative open heaters because their present form is based on a longer and larger experience, better facilities and the thoroughness that comes from determined effort to build up a business. The Horse Power Capacity of Cochrane Heaters now in use is not approached by that of any other make.

If you wish to utilize exhaust steam for heating or drying or if you wish to improve the economy of your boiler plant by feeding the boilers at all times with hot, soft water that will not form scale, or if you desire to use hot, soft water for other purposes, it will undoubtedly be worth your while to take advantage of the advice and suggestions of our Engineering Department.

Ask for Treatise "15-H" on "The Profitable Utilization of Exhaust Steam."

HARRISON SAFETY BOILER WORKS

17th and Clearfield Sts., Philadelphia, Pa.



Nelson Valves

A close inspection of the New Nelson Medium Pressure Bronze Gate Valve reveals the reasons for its fine superiority.

Strength values greater than ordinary are gained by the substitution of curves for the commonly used straight lines.

The outside bonnet, screwed snugly over the body, adds largely to this unusual strength, and fortifies the body against severe shock.

Still further strength is acquired by the strict use of carefully selected pure valve bronze.

Self-adjusting, tapered double discs, packing chambers easily packed under full pressure, and a simple, effective mechanism, unite with the strength features to produce the very best bronze gate valve made.

Each valve is tested to 500 pounds, leaving ample margin for our absolute and express guarantee for service at working pressures up to 175 pounds.

Strength and harmony are suggested by its appearance; its honest efficiency is established by its use.

The Nelson Valve Company,
Philadelphia.

New York, Hudson Terminal Bldg.
Chicago, 40 Dearborn Street
Pittsburgh, 525 Third Avenue
Minneapolis, 622 Andrus Bldg.
San Francisco, Atlas Building

PEERLESS SPIRAL PISTON AND VALVE ROD PACKING

IS THE MOST SATISFACTORY PACKING IN THE WORLD.
IT WILL RUN FROM 12 TO 16 MONTHS WITHOUT REPACKING.
WILL HOLD 400 POUNDS OF STEAM.
IT WILL PACK TIGHTLY ANY ROD HOWEVER BADLY SCORED AND CORRODED.
WILL NOT GET HARD UNDER ANY DEGREE OF HEAT.

SOLE MANUFACTURERS OF THE CELEBRATED
RAINBOW PACKING

PATENTED MANUFACTURED EXCLUSIVELY BY

THE PEERLESS RUBBER MANUFACTURING COMPANY

16 WARREN ST., NEW YORK

DETROIT, MICH. - 16-24 WOODWARD AVE.
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PARIS FRANCE. - 76 AVE DE LA REPUBLIQUE.
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JOHANNESBURG, SOUTH AFRICA: - 2427 MERCANTILE BL'D'G
COPENHAGEN, DEN - FREDERIKSHOLMS KANAL 6.
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INDIAN RED SHEET PACKING

Stays Where It's Put.

Ask Any Engineer Who's Used It.

Practically without *advertising* or other stimulation, the annual *sales* of *INDIAN RED SHEET PACKING* have grown from thousands of *pounds* to *thousands* of tons. Many engineers will *have nothing else.*

The Reason—SERVICE, DEPENDABILITY, RELIABILITY.

Our New Catalogue covers PACKING, BELTING, HOSE, VALVES, ETC., very fully. Shall we send it?

The Diamond Rubber Co.

Akron, Ohio

COMPLETE DIAMOND STOCKS CARRIED BY

THE DIAMOND RUBBER CO., OF N. Y., 1876 Broadway, N. Y.
THE DIAMOND RUBBER CO., OF N. Y., 304 N. Broad St., Phila., Pa.
THE DIAMOND RUBBER CO., 1523 Michigan Ave., Chicago
THE DIAMOND RUBBER CO., 3963 Olive St., St. Louis, Mo.
THE DIAMOND RUBBER CO., Mission and 2nd Sts., San Francisco, Cal.
THE GUSTIN-BACON MFG. CO., Kansas City, Mo.
BUFFALO MILL SUPPLY CO., Buffalo, N. Y.
PITTSBURG RUBBER & LEATHER CO., Pittsburg, Pa.
SOUTHERN HARDWARE & SUPPLY CO., Mobile, Ala.
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CONSUMERS RUBBER CO., Cleveland, Ohio
M. I. WILCOX CO., Toledo, Ohio

Cobbs High Pressure Spiral Piston and Valve Stem Packing

The Rubber core is made of an oil and heat resisting compound, wrapped with a well frictioned Duck, with an outer cover of fine asbestos, lubricated by our secret process.

It is made round or square, in coil or spiral form especially adapted to withstand heat and high pressure. We guarantee "Cobbs" Packing will pack any rod perfectly tight, as it will not get hard under any degree of heat.

"Cobbs" Packing also furnished in rings at short notice, made of round or square packing.

Indestructible White Sheet Packing

Is without doubt the toughest and most durable High Pressure Sheet Packing on the market. It will stand the highest pressure and extreme heat, making a tight joint when used for Steam, Air, Hot or Cold Water.

It does not dry out or become hard and brittle, but retains its tough elastic qualities, either in or out of service. Ammonia, Liquor, Alkali, Oils or Acids have little or no effect on it, and joints can be broken numerous times without renewing the packing.

Indestructible White Sheet Packing is also made with wire insertion.

We manufacture a complete line of high class rubber goods, comprising Belting, Air, Fire, Garden, Steam, Suction, Pneumatic Tool and Water Hose Packings, Gaskets, Mats, Matting, Stopples, Special Mould Goods, Interlocking Rubber Tiling, Tubing, etc.

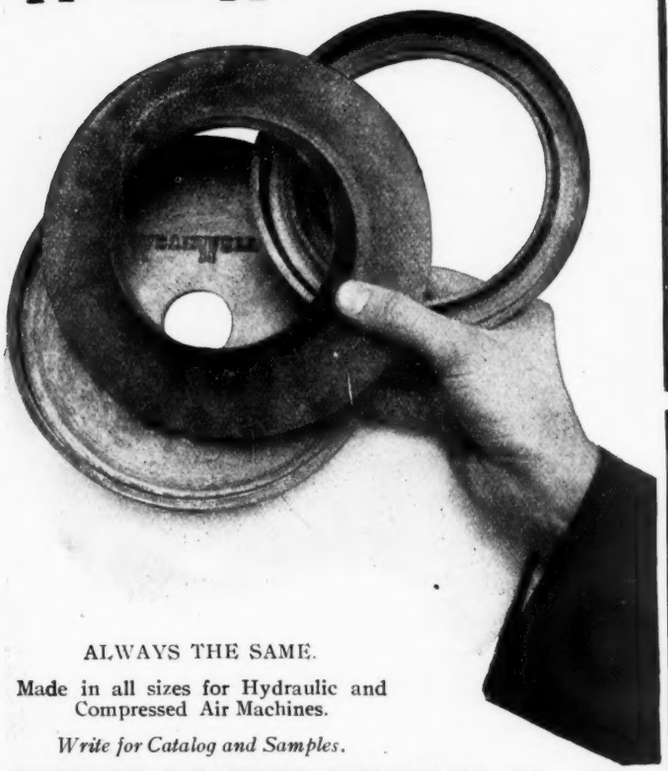
SOLE MANUFACTURERS

New York Belting & Packing Company, Ltd.

91 and 93 Chambers Street, New York, N. Y.

CHICAGO, 150 Lake St.
ST LOUIS, 218-220 Chestnut St
PHILADELPHIA, 118-120 N. 8th St.
SAN FRANCISCO, East 11th St and 3d Ave., OAKLAND.
BOSTON, 232 Summer St
INDIANAPOLIS, 229 S Meridian St.
BALTIMORE, 114 W. Baltimore St.
BUFFALO, 600 Prudential Bldg.
PITTSBURG, 913 915 Liberty Ave.
SPOKANE, WASH., 163 S. Lincoln St.
LONDON, E C., ENGLAND, 58 Holborn Viaduct.

WEARWELL LEATHER **WEARWELL** PACKINGS



ALWAYS THE SAME.

Made in all sizes for Hydraulic and Compressed Air Machines.

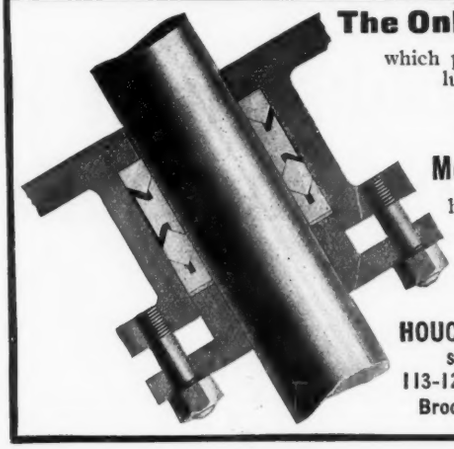
Write for Catalog and Samples.

DETROIT LEATHER SPECIALTY CO., INC.,

175 Beecher Avenue, Detroit, Mich.

The Only Packing

which permits perfect lubrication.



LAW

Metallic Packing

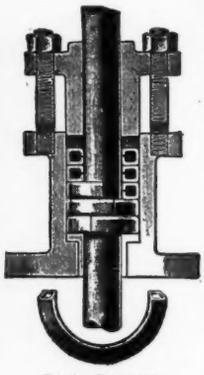
has annular spaces between its rings through which the lubricant enters. *Write.*

HOUCHIN-AIKEN CO.,

Sole Manufacturers,

113-121 Fifty-third Street,

Brooklyn, New York.



U. S. Patents

HUHN PACKING

is positively the only packing which lubricates the rod perfectly and in exact proportion to the requirements produced by friction.

On account of this **SELF LUBRICATING** feature alone, this is the most economical packing on the market.

Write for a sample and our booklet.

American Huhn Metallic Packing Co.

1876 Broadway, New York

American Asbesto-Metallic Packing.

Perfect for high pressure. Semi-metallic, packs like fibrous packing, wears like metallic and gives more satisfaction than either. Ask us just how it is made, or, better yet, get a sample and see for yourself.

American Steam Packing Company,

51 High Street, Boston, Mass., U. S. A.

Uncle Sam's torpedo boats use

TORPEDO ASBESTOS PACKING

because Uncle Sam's expert engineers consider it the best.

CIRCULAR?

OSGOOD SAYEN

421 Arcade Building PHILADELPHIA, PA.

The Improved

Tripp Metallic Packing

Manufactured Solely By

TRIPP METALLIC PACKING CO. 74 India St. Boston, Mass.

ELEPHANT BRAND

DELTA

REG. U. S. PAT. OFF.

THE PHOSPHOR BRONZE SMELTING CO., Limited.

2200 WASHINGTON AVENUE, PHILADELPHIA, PA.

ELEPHANT BRAND *Phosphor Bronze*

INGOTS, CASTINGS, WIRE, RODS, SHEETS, Etc.

— DELTA METAL —

CASTINGS, STAMPINGS AND FORGINGS

ORIGINAL AND SOLE MAKERS IN THE U. S.

"SAFETY"

PLASTIC

METALLIC PACKING

For Steam, Water, Air, Gas, Hydraulic Machines, Valves, Etc.

Guaranteed to stand Steam Temperature up to 550° F. and Hydraulic Pressure to 5000 lbs. per square inch.

Highest Award World's Fair, St. Louis.

Send for **FREE SAMPLE** and particulars.

MANUFACTURED BY

STEEL MILL PACKING CO., Detroit, Mich., U.S.A.

U.S. METAL POLISH

G. W. Hoffman, Sole Prop. 295 E. Wash. St. INDIANAPOLIS, IND.

TRADE MARK.

INFALLIBLE

FOR POLISHING GOLD, SILVER, PLATED WARE, NICKEL, TIN, BRASS, COPPER, Etc.

DIRECTIONS:

Take a little of the Polish on a soft cloth, rub the Metal hard and then wipe it off with a dry cloth.

A SHINE ALL THE TIME

is the order of things where U.S. Metal Polish is used. The lustre lasts. Write for free samples.

3-oz. Box, 10 cts.
5 lb. Pail, $1.00.
1 gal. Liquid, $1 00.

AT DEALERS.

GEO. W. HOFFMAN—Expert Polish Maker,

295 East Washington Street, Indianapolis, Ind.

New York City. Chicago, Ill. San Francisco, Cal.

PALMETTO

PACKING FOR
HIGH SPEED ENGINES

Engines running at high speed should have as little stuffing box friction as possible.

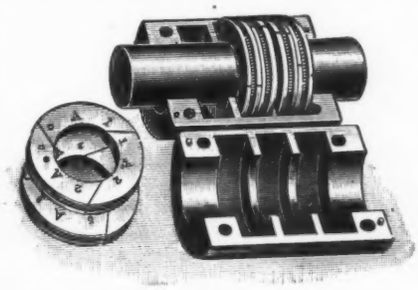
PALMETTO is practically a frictionless packing, because it is constructed on what we call the unit plan (each strand carrying its own lubricant independently). It is almost impossible to make you understand what it means to relieve your engine of the usual stuffing box friction load, caused by the use of ordinary packings, except by actual proof, and that we are prepared to furnish by giving you FREE working samples. Send for them.

GREENE, TWEED & CO.

SOLE MANUFACTURERS

109 DUANE STREET - NEW YORK

The great success of Bridgeport Improved Ring Packing is due primarily to its flexibility. No matter how badly the engine is out of line, the packing floats with rod, offering very little resistance.



Bridgeport Improved Ring Packing is simple, durable and easily applied without disconnecting rods. It has no square shoulders to limit wear of rings. You can have it on 30 days' trial.

The Bridgeport Metallic Packing Co., - 629 Railroad Ave., Bridgeport, Conn.

THE PACKING WITH REAL HOLDING QUALITY

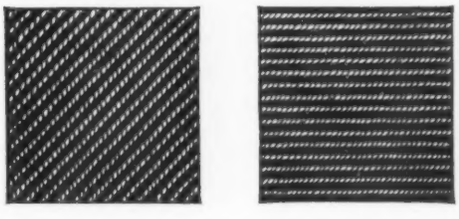
Pat. March 15
1898

DODS Diagonal Piston Rod Packing

is all one piece, made from high-grade Rubber and Duck in layers placed at a diagonal from every side. This construction gives "Dods" a cross expansion of 100%. It will hold steam, air or liquids when all other packings fail.

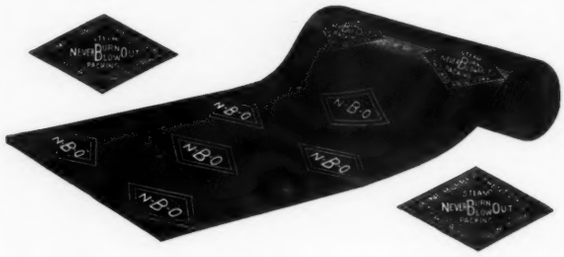
Send for test samples and description. Address Dept. P.

CROSS-SECTIONS OF
"DODS" PACKING. ORDINARY PACKING.



☞ These Cross-Section Views Show Why!

CHICAGO **BOWERS RUBBER WORKS** SAN FRANCISCO



N. B. O.

The Famous and Original Black Sheet Packing.

Beware of imitations.
Remember, they can never duplicate the *quality* of genuine N. B. O. It's the original black sheet packing that refuses to burn, blow, squeeze or rot out. Made of the best stuff and is reliable under all conditions.

O. I. M. on its merit

High Pressure
Use where pressure is above 100 lbs.

O.I.M. Packing

is made with two diagonally cut wedges which slip on each other with extreme readiness and adapt themselves to any surface variations on scored and uneven rods.
If your dealer cannot supply you, write to us direct. At all events try N.B.O. and O.I.M. without delay.

O. I. M. on its merit

Low Pressure
Use where pressure does not exceed 100 lbs.

Home Rubber Company,

Woolverton Avenue, Trenton, N. J.

New York
80 and 82 Reade St.

Chicago
54-60 S. Canal St.

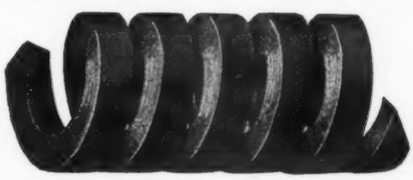
London—Balfour House
Finsbury Pavement.

From Gum Core to Canvas Cover

ZENA

is honestly made, from generous quantities of material, a little better than would seem necessary, and by men who have made a life study of packing construction. Write.

Randolph Brandt, 72 Cortlandt St., New York.

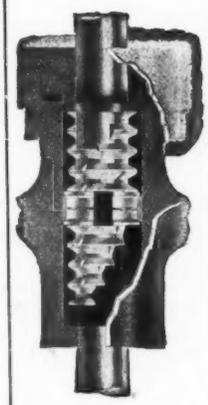


INSIDE FACTS
ABOUT JOHNSON'S PACKINGS

We won't burden you with a hot air yarn about "secret formulas"—*we have none.* Just remember that we use nothing but the very highest grade material in liberal quantities. That tells the story. Catalog ?

THE HENRY JOHNSON COMPANY
175-187 GATES AVENUE, JERSEY CITY, N. J.

Sterling Metallic Packing
A Perfect Packing for Steam, Air, Gas and Ammonia Rods.



Sterling Improved Metallic Packing consists of a series of packing rings which automatically adjust themselves to the extreme expansion and contraction of the rods.

Note cut. The outside packing is of fine German asbestos. Metal rings are put through a hot press under very high pressure and are held to the rod by a steel spring. **Positively holds ammonia, steam, gas** or **air.**

CATALOG?

MONARCH STEAM BLOWER CO.
Troy, N. Y.

Five Different Packings

Eureka Gum Core (the kind you know), Eureka Cut Ring, High Pressure, Water Proof and Red Sheet Packings. Do you know them all?

THIS LABEL ON PACKING "EUREKA" TRADE MARK. IS A GUARANTEE OF EXCELLENCE.

Cut Ring and in Spiral Form

Made to measure for any size rod and stuffing box. Guaranteed highest quality.

High Pressure in Coils and Rings

is practically indestructible, as it is not affected by pressure or heat.

Water Proof in Coils and Rings

is invaluable for all cold water purposes, such as pump pistons, hydraulic elevators, etc.

Red Sheet

makes a perfectly tight joint on steam, gas or ammonia connections.

Prices and Delivery will interest you.

Write for them.

Eureka Packing Company
Jas. L. Robertson, President
46 Warren Street, NEW YORK

You can't get good work out of a man who easily "goes to pieces".
You can't get good service out of a packing that goes to pieces.
MARCO diagonal packing absolutely can't be rubbed apart. It will out last any other diagonal at least four or five times. Have you tried it? Just drop us a line and get a sample. Then you can see for yourself.

MARCO Packings are manufactured by

THE CLEVELAND RUBBER WORKS

OF THE MECHANICAL RUBBER COMPANY

68 LISBON RD. CLEVELAND, OHIO

TRADE MARK
N.I.R.
RED SHEET PACKING
Unsurpassed for Durability.
Unaffected by extreme temperatures.
Impervious to action of gases, liquids and ammonia. Made of best grade rubber compound and finest quality asbestos fibre.
Guaranteed to withstand the highest steam pressure.
NATIONAL INDIA RUBBER CO.,
Factory: BRISTOL, R. I.
BRANCHES: 42 Broadway, New York. 84 Lake St., Chicago. 101 Milk St., Boston.
37 Hopkins Pl., Baltimore. 379 Washington St., Buffalo.

BELMONT

HIGH PRESSURE STEAM PACKING.

See the wedges ?

Each one is woven from the finest long stock asbestos from which all metallic particles have been removed by the magnetic process.

The back to which these are cemented is composed of a special rubber compound which will not become brittle or disintegrate under **highest steam pressures.** The entire packing is lubricated with the very highest grade of graphite, in connection with our special high test lubricating compound, so that **BELMONT HIGH PRESSURE WEDGE PACKING** is absolutely non-friction in character throughout—cannot carbonize or dry out under any steam pressure or temperature, and will give better, safer and longer service than any other packing ever made.

It is an especially excellent packing for **high speeds** and **high pressures** on **steam, gas** or **marine** engines; and when exposed to **superheated steam.** *Illustrated catalog mailed on request.*

FREE!

SEND FOR A SAMPLE RING AND BE CONVINCED.

CLEMENT RESTEIN CO.,
Philadelphia, Pa.

Gentlemen :—
Send me a sample ring of BELMONT HIGH PRESSURE WEDGE PACKING, Style No. 50.

Name.....
Address.....
Firm Name.....
Number of Engines.....
Number of Pumps.....
Number of Boilers.....
High or Low Pressure.....
Packing now in use.....

Power, 8-4 08.

CLEMENT RESTEIN CO.,
133 North Second St., PHILADELPHIA, PA.

Possibilities of Salary Raising

F. L. RAY

THE possibilities of your securing a raise in salary depend 90% on one thing—upon your securing the knowledge and **training** that will really qualify you to hold a higher position commanding a larger salary. Such training has helped thousands of men in the same way that it helped Frederick L. Ray to advance from work as a machinery erector to power superintendent for the Stanley Rule & Level Company, of New Britain, Conn., and later to superintendent of construction for W. M. Sheehan & Co., New York City. Mr. Ray's earnings have, of course, increased very largely since he became an I. C. S. Trained man—for it was through the I. C. S. that he secured his training. It is **training** that counts. You **must** bring training into your work today if you wish to secure anything above a subordinate position with low wages.

The quickest, surest, and most practical way in the world to secure this training is by the plan of the International Correspondence Schools, an institution backed by a capital of six million dollars and with nearly 17 years' experience in the sole business of providing ambitious men with salary-raising training. You do not have to leave home or your present work. Full details of how this plan can be adapted to **your personal needs and circumstances,** no matter how scant your time, money, or education, will be sent free to any one marking and mailing the coupon below. This puts you under no obligation. If you really want a better position use this coupon **now.**

INTERNATIONAL CORRESPONDENCE SCHOOLS
Box 979, Scranton, Pa.

Please explain without further obligation on my part, how I can qualify for a higher salary and advancement to the position before which I have marked X.

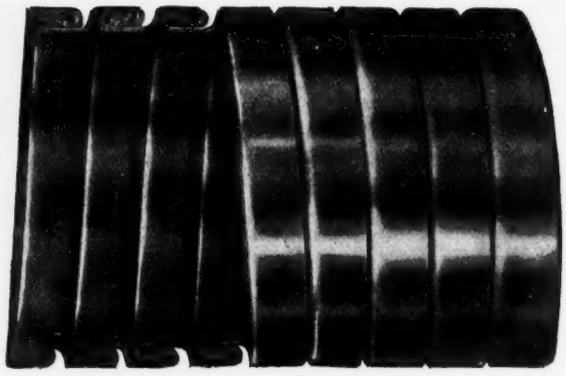
Electrical Engineer	Machine Designer	Sanitary Engineer
Elec.-Lighting Supt.	Mechanical Draft.	Architect
Elec.-Railway Supt.	Foreman Machinist	Architectural Draft.
Electrician	Foreman Toolmaker	Ad Writer
Telephone Engineer	Foreman Molder	Window Dresser
Civil Engineer	Foreman Blacksmith	Chemist
Bridge Engineer	Marine Engineer	Sheet-Metal Draft.
Mechanical Engineer	Hydraulic Engineer	Ornamental Design.
Stationary Engineer	Municipal Engineer	Textile Designer
Gas Engineer	R. R. Construc. Eng.	Bookkeeping
Refrigeration Eng.	Surveyor	Stenographer
Traction Engineer	Mining Engineer	Civil Service Exams.

Name _____

St. and No. _____

City _____ *State* _____

Interlocking Edges Enclose An Asbestos Thread



Pennsylvania Flexible Metallic Tubing made in all sizes $\frac{1}{8}$" to 12"

For High Pressures

and guaranteed to hold steam, compressed air, gases, ammonia, oils or any other liquid. More flexible than rubber hose and as strong as solid metal pipe. *Circular?*

PENNSYLVANIA
Flexible Metallic Tubing Co.

S. H. COLLOM **1305 Arch St., Philadelphia, Pa.** H. A. ANSELL

NEW YORK, 86 Warren St. BOSTON, 71 High St. CHICAGO, 255 LaSalle St.

SALESMEN WANTED

In most of the large cities and supply centers, to sell the Wilcox Patented Self-Sealing Gasket, on a commission basis. We already have an established trade with a majority of the largest and best appointed plants in the United States.

E. A. WILCOX MFG. CO., CHICAGO, ILL.

We'll Pay Costs

of the trial on the worst joint you can find in your plant.

Goetze's Elastic Copper Gasket

will not blow out at any pressure or temperature and they last without attention for years.

SEND SIZE.

American Goetze-Gasket & Packing Company
525 East 149th St., New York City

IN STOCK FOR PROMPT SHIPMENT.

BOILERS.
4 72"x18', 125 lbs. pres., "Wickes," NEW.
4 72"x16', 125 lbs. pres., "Wickes," NEW.
1 300 H.P. "Wickes" vertical water tube.
3 200 H.P. "Geary" water tube.
1 150 H. P. "Wickes" horizontal water tube.
500 H.P. "Seabury" marine boiler.
100 H.P. "Economic" portable boiler.

ENGINES.
2 38"x72" modern heavy duty, "Corliss," practically NEW.
30"x72" R. H. "Corliss."
30"x60" "Rankin & Fritsch" Corliss.
28"x60" "Harris" Corliss. 23"x60" "Corliss."
19" and 38"x48" "Allis" Corliss.
28"x56" L. H. "Buckeye" automatic.
15"x17" automatic vertical.

AIR COMPRESSORS.
18½"x11¼"x4" "Ingersoll-Sergeant."
18"x18"x18" "Laidlaw-Dunn-Gordon."
16"x15"x16" "Straight Line."
16"x10"x10" "Blaisdell," Class A. C.
12"x16"x14" "Hall" Straight line.
11" and 6"x6" "Pedrick & Ayer," No. 1.
10"x18"x18" "Snder-Hughes."
10"x10½"x7½"x12" D'Auria, duplex comp.

CONDENSERS.
1400 H.P. "Wheeler" surface condenser, with combined vacuum and circulating pump, two 12" exhaust inlets.

DUPLEX PUMPS.
20"x8"x16" "Canton," 6" dis.
17"x7¼"x15" "Worthington," 4" dis.
16"x12"x10" "Smith-Vaile," 7" dis.
14" and 20"x12"x12" comp., 10" dis.
14"x14"x18" "Hughes," 10" dis.
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50 K.W., 110 Volt, 1000 light, Gen Elec., direct connected to 10" and 14"x14" "Russell" tandem comp, automatic engine.
50 K.W., 125 Volt, 1000 light, Commercial direct connected to 11"x14" Buckeye style C., automatic engine.
16 K.W., 80 Volts, Gen. Elec. generator, direct connected to 8½"x6" double, vertical automatic engine.
15 K.W., 125 Volts, 300 light, Westinghouse direct connected to 7½"x10" L. H. auto. engine.

DIRECT CURRENT GENERATORS.
100 K.W., 250 V., 2000 Lt., "Milwaukee."
80 K.W., 125 V., 1600 Lt., "Westinghouse."
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27½ K.W., 110 Volt, 550 Lt., four-pole.
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Send for monthly stock lists of refitted machinery and power equipment. Prompt shipment of all items listed.

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WE have purchased the great stock and business of the firm of Kelly-Maus & Co., Chicago. And July 1st this old established business became our own.

¶ To the customers of Kelly-Maus & Company we extend cordial greetings and a hearty welcome to the larger business into which their old source of supply has been merged, and we offer better facilities for executing their orders with *instant promptness* from a stock many fold larger and more varied.

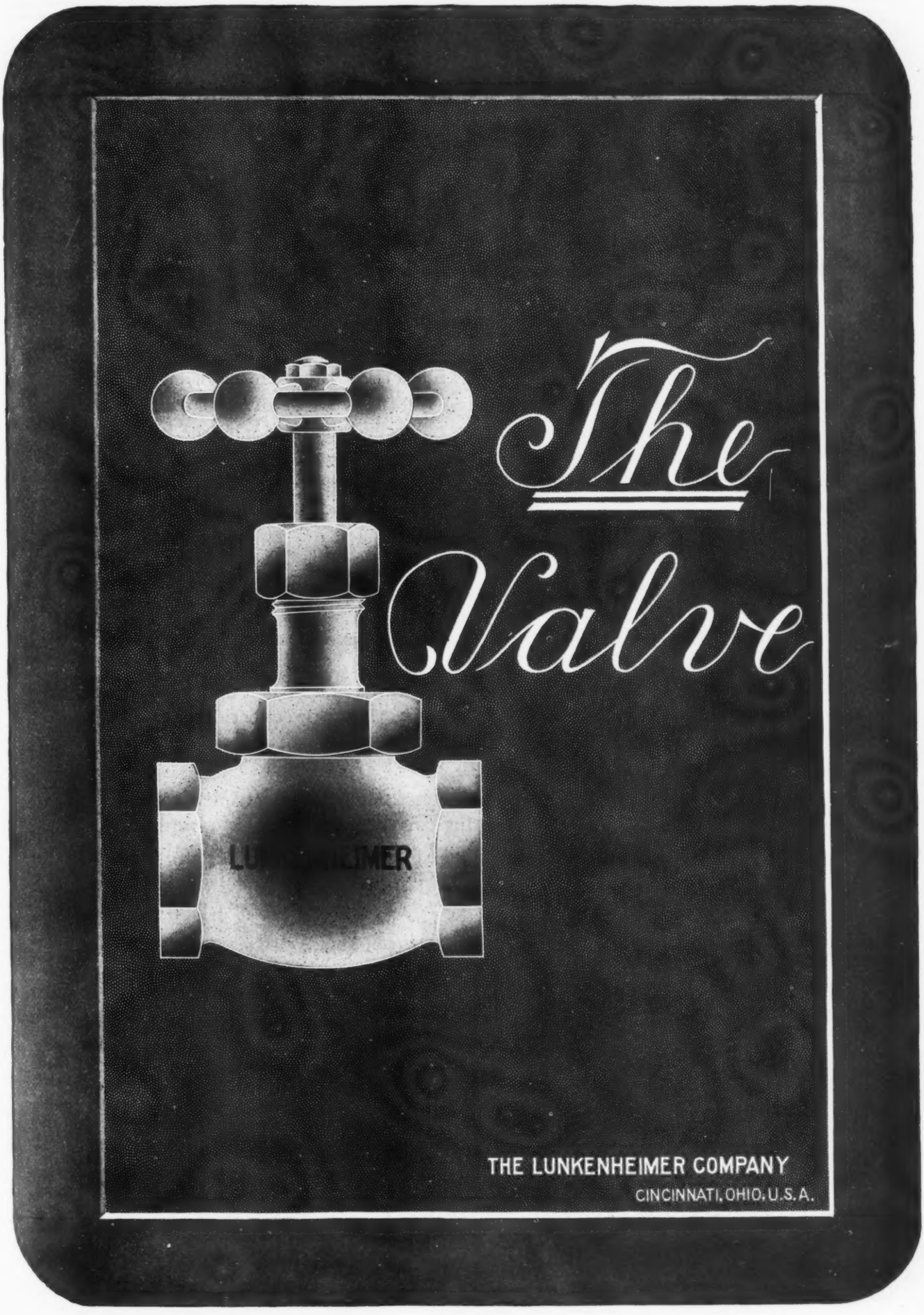
¶ To our own patrons, this merger also means much, and it is a source of much satisfaction and pleasure to feel that this enrichment of our stock and enlargement of our business will enable us to serve them better than ever before.

¶ The new SCULLY BLUE BOOK tells the whole story and offers the most complete line of raw and semi-finished materials, as well as supplies for every class of worker in iron and steel, that has ever been assembled under one management in the industrial history of the world. The book is free—may we send it?

Yours sincerely,

SCULLY STEEL & IRON CO.,
CHICAGO

By this merger the CHICAGO IRON STORE, Randolph St. Bridge, takes over the old Kelly-Maus stock of Horseshoers', Wagonmakers' and Blacksmiths' Supplies. This stock is also subject to the call of the customers of Scully Steel & Iron Co.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THE LUNKENHEIMER COMPANY
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EVERY engineer handling a motor knows, either from sad experience or the experiences of others, that his motors are liable to develop trouble at any stage of the game. Likewise he knows the serious effects of motor troubles—the time lost, the money wasted and the labor involved in tracing, locating and remedying the difficulty. What every engineer needs and what he has never had the opportunity of getting heretofore is a book which could be absolutely depended upon to give the simplest and most effective methods of tracing and correcting direct and alternating-current motor troubles. The book is here now. And its title is

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causes loss of steam and lost steam must be replaced at fuel cost.

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means production of condensation water and this water makes engine repairs necessary.

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can be checked by the use of Carey's 85% Carbonate Magnesia Pipe Coverings and these coverings save coal.

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are used almost exclusively by the U. S. Government which is a good guarantee of their worth.

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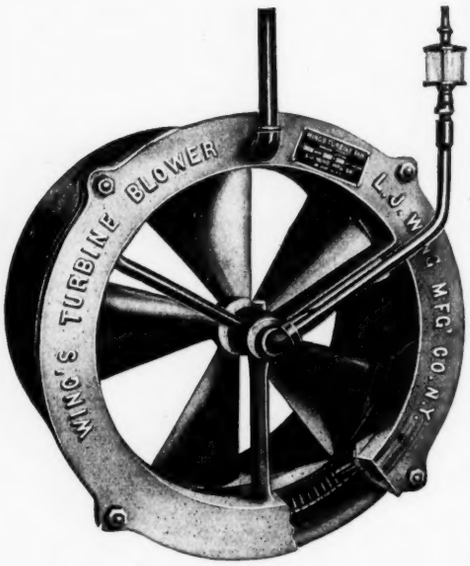

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keeps the boiler temperature steady even when the fire door is opened.

It makes profitable the burning even of very cheap grades of coal.

It is moderate in price, easy to install, occupies no extra space and requires very little attention.

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Designers and Builders of Heating and Ventilating Systems

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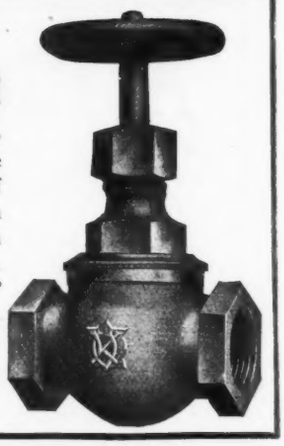

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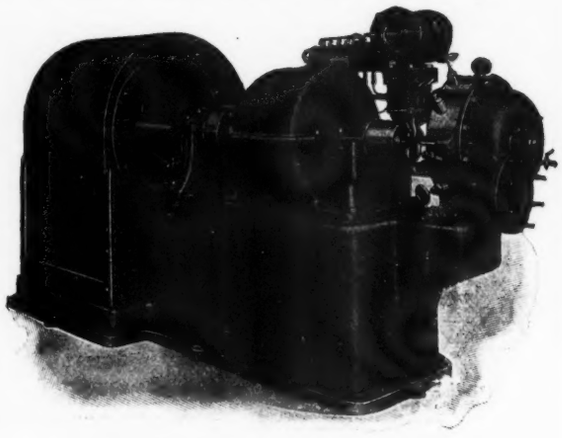
BLOWERS

BUILT ON THE TURBINE PRINCIPLE
MOST EFFICIENT FOR ALL DUTIES



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20" Double Inlet Sirocco Blower, Direct connected to a steam turbine for forced draft. Capacity of 28,000 cu. ft. against a pressure of 5½" water gauge. EFFICIENCY 65%.

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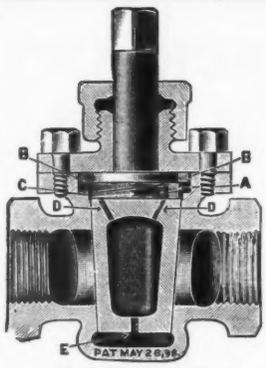

Homestead Straightway Balance Plug Valve Locks by Quarter Turn

An Ordinary Valve When New Is Not As Good As An Old "Homestead"

That's true because of the wonderful wear-proof qualities of Homestead Valves. Seats are absolutely protected from wear when pressure passes through and there is no friction in seat while plug is turning. Homestead Valves are made in Straightway, Three-Way, Four-Way, Locomotive Blow-Off, Angle styles, etc. Ask for booklet.

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"THE ANDERSON"

Cushioned Non-Return and Triple Acting

"Works Both Ways"

"The Life and Property Insurance Valves"

Protect Your Power Station with the Valves that are Absolutely Guaranteed.

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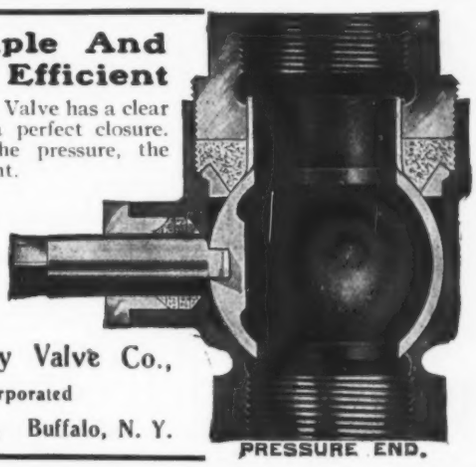
"3 VALVES IN ONE"

Angle or Globe

So Simple And Yet So Efficient

The Huxley Valve has a clear opening and a perfect closure. The higher the pressure, the tighter the joint.

Kindly mention "POWER" when writing.



The Huxley Valve Co.,

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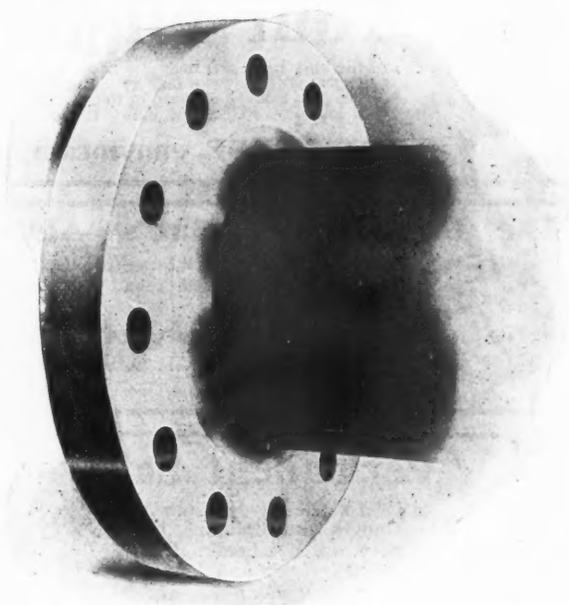

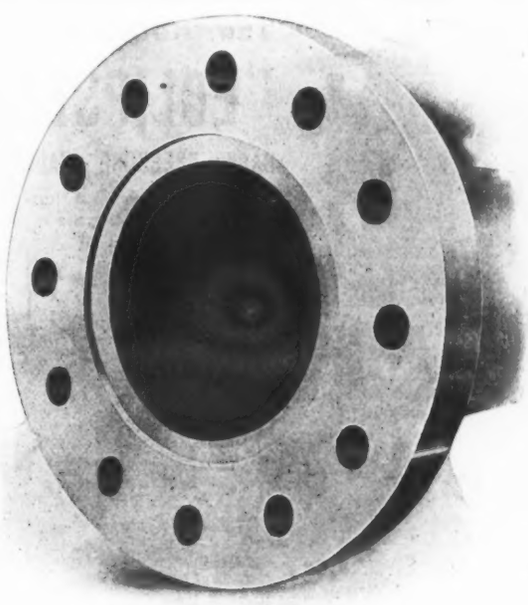

Bailwood Welded Flanges are so made, of such material, that they become integral parts of the pipe, expanding and contracting with it, thus making a perfectly leakless joint.

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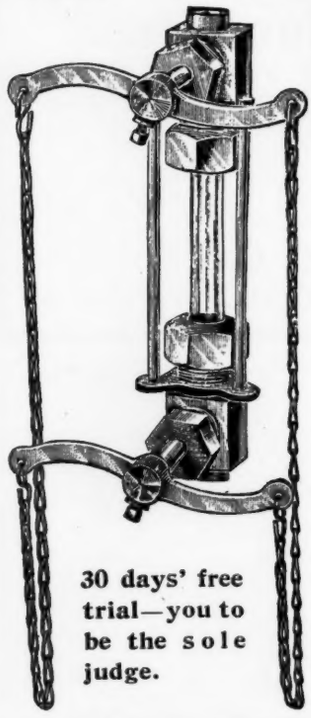
YOU CAN ESCAPE WITH A WHOLE SKIN



30 days' free trial—you to be the sole judge.

the next time the gauge glass breaks, provided you use the "P. B. H." Quick Closing Water Gauge.

When the scalding steam and water come hissing out, just stand at a safe distance and pull the chain shutting them off as easily as turning out the gas.

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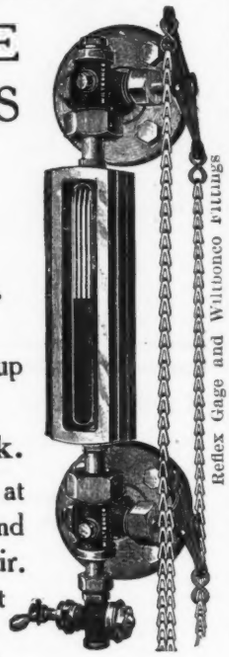
The PAUL B. HUYETTE COMPANY, Inc.
2025 BETZ BUILDING, PHILADELPHIA.

SEE HOW **BLACK** AND **DISTINCT** THE WATER SHOWS



Reflex Water Gages show up clear and sharp.

The Water Shows Black.

Anyone with eyes can read it at a glance. Easy to mount and not affected by cold drafts of air. Used bythe world's greatest navies.

CATALOG?

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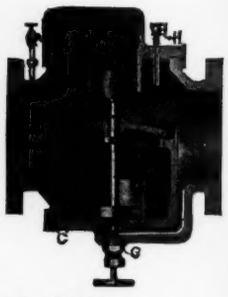
The HOCHFELDT
"ECLIPSE"
BACK PRESSURE VALVE
For Condensing and Non-condensing Plants



This valve in principle of construction has many points of superiority over any similar valve on the market. It is the most durable and sensitive valve made. It is absolutely noiseless and tight under vacuum. Impossible for a valve to chatter under any conditions. Special circular illustrating and describing it, gives full particulars.

"ECLIPSE STEAM SPECIALTIES"

"ECLIPSE"
- REDUCING VALVE
- LOW PRESSURE REGULATING VALVE
- BACK PRESSURE VALVE
- VACUUM PRESSURE REGULATING VALVE
- AUTOMATIC PUMP GOVERNOR
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Distinctive points of merit in principle of construction, supported by the best of material and superior workmanship—count for the satisfactory performance of every device in use.

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Your Fingers

are the only tools you need to pack your glasses tight, *provided* you use Gilbert Gauge Glass Preservers. No trouble, expense or toil. A *SAMPLE BOX* costs 60c. Get one!

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The Gage Of A Man's Ability

decides the size of his salary—the use of Ashton Steam Specialties helps you to fill a broad gage. Write.

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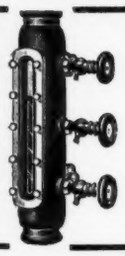

Permanent Safety

is assured by Reliable Water Gauges and Columns, because they will not break. They are easy to attach and always efficient. *Circular?*

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Erwood Swing Gate Valves

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IF YOU ARE INTERESTED IN POWER PLANT EQUIPMENT YOU WILL BE INTERESTED IN

PITTSBURGH BRASS GLOBE VALVES

THEY are made as nearly perfect as the best skilled mechanics and newest approved machinery will allow.

THEY ARE MADE OF HIGHEST GRADE STEAM METAL and ARE UNCONDITIONALLY GUARANTEED.

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GENERAL OFFICES and WORKS, BARBERTON, O.

We manufacture all kinds of Valves and Fittings.

Schutte

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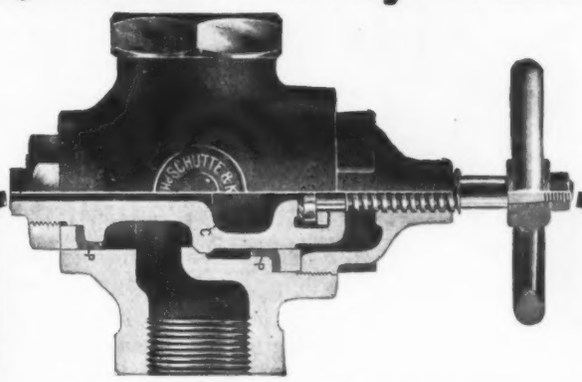

Is highly adapted for use on step bearings of turbines.

Is balanced above and below seat—therefore immaterial how placed in pipe line—will seat equally well in any position.

This valve will stand a working pressure of 1500 lbs. and is guaranteed to withstand a pressure of 3000 lbs. per sq. in.

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GIVE ME A LUDLOW VALVE EVERY TIME

says the man who has tried 'em all.

"There's less wear on faces of gates and seats.

There's higher quality and better workmanship.

There's longer life and greater reliability."

TRADE "LUDLOW" MARK Valves are thoroughly tested, fully guaranteed and made in all sizes for all purposes. *Write for catalog.*

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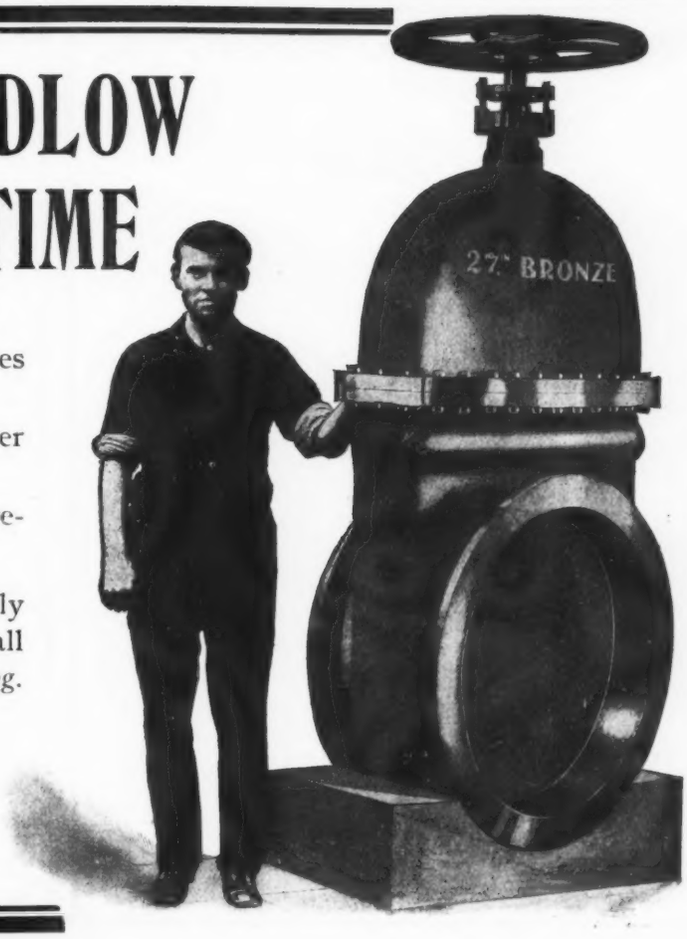

DAVIS PRESSURE REGULATORS SAVE STEAM

PRESSURE REGULATOR

Do It Automatically

If you are using live steam for heating, drying, cooking or some other purpose at a pressure lower than that carried on the boiler, let the Davis Pressure Regulator make the reduction for you automatically.

This valve can be adjusted to deliver steam at just the pressure needed and it will maintain that pressure without fluctuations no matter how much the initial boiler pressure may vary.

Reducing steam by throttling through a cracked globe or gate valve is about as satisfactory as using saw dust for fuel. You may be able to get along after a fashion, but why not do it right—automatically.

If you are running your engine non-condensing a Davis Automatic Back Pressure Valve will enable you to make use of the exhaust steam instead of letting it go to waste.

Contrast this valve with its semi balanced disc, small weight and noiseless operation without any possibility of injury to the seats, with the old style single seated valve which pounds like a trip hammer and keeps you poor buying seats for it. Is there any comparison—would you choose the single seat ?

Send for a complete catalog of Davis Valve Specialties. It is of interest to both owner and operator.

G. M. Davis Regulator Company,

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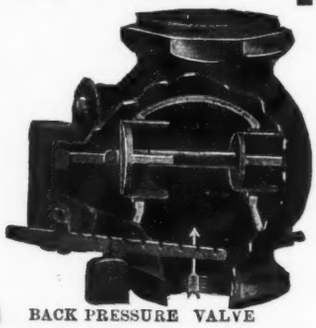
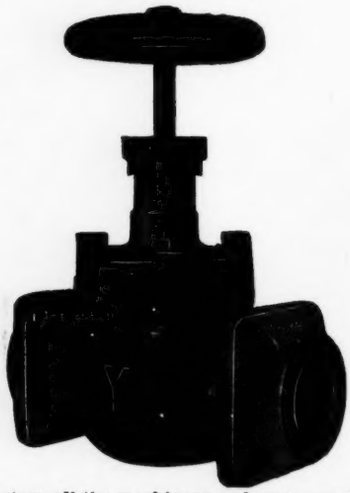


BACK PRESSURE VALVE

YORK MANUFACTURING CO.,

YORK, PA.



We manufacture all the machinery and parts needed to equip a complete Ice or Refrigerating Plant—Machines, Condensers, Tanks, Cans, Coolers, Piping, Boilers and Ammonia Fittings of all kinds.

We employ over 1250 men in the manufacture of Ice and Refrigerating machinery exclusively.

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Our fittings carried in stock at the following places:

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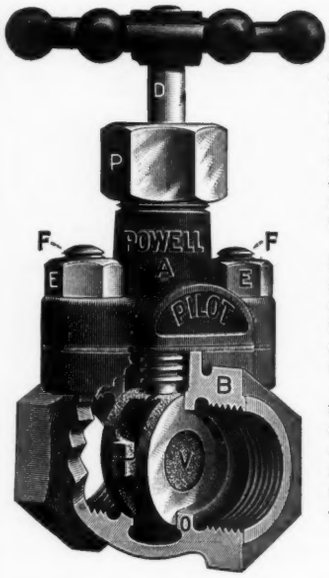
The Powell PILOT

BRASS MOUNTED GATE VALVE



A DOUBLE DISC Iron Body Gate Valve for medium pressures. The body is strong and compact with heavy lugs carrying stud bolts E. The stud holes in lugs of bonnet cap A, being accurately drilled to template, permit the valve to be assembled any old way. No matter how you handle it, after taking apart, it always fits.

THE DOUBLE BRASS DISCS, made adjustable by ball and socket back, are hung in recesses to the collar on the lower end of the stem. Stem is cut to a true acme thread, the best for wear.

The Powell Pilot Gate Valve is also made all iron. For the control of cyanide solutions, acids, ammonia, and other fluids that attack brass it has no equal. Send for special circular.

If YOUR jobber does not have them in stock —ask us who does.

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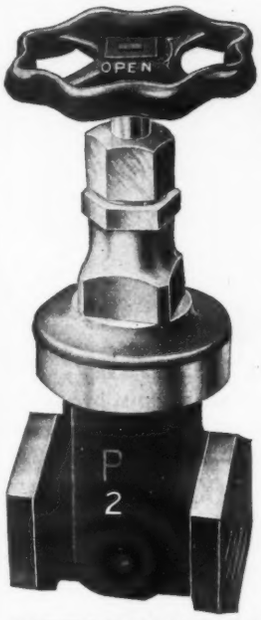
NEW YORK, 254 Canal St. PHILADELPHIA, 518 Arch St.
BOSTON, 239-245 Causeway St.



PITTSBURGH BRASS GATE VALVES

are made of highest grade steam metal. They are designed for 150 pounds working pressure of steam, water or air. They are made with a patent elliptical nut lock, which prevents packing nut from turning when the valve is opened.

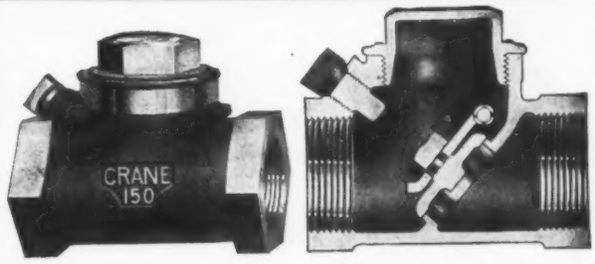
PITTSBURGH BRASS GATE VALVES

are finished by the most modern and approved machinery and are unconditionally guaranteed.

PITTSBURGH VALVE & FITTINGS CO.

General Offices and Works—BARBERTON, OHIO.

We manufacture all kinds of Valves and Fittings.



STRAIGHT-WAY CHECK VALVES

WITH REGRINDING SEATS

THESE valves are designed for the most exacting service, on pressures up to 150 pounds. All parts are made of a superior bronze mixture. The distribution of metal gives ample strength without unnecessary weight.

Valves have full area and operate horizontally or vertically.

The seat is placed at such an angle that the force of impact of disc is reduced to the minimum, decreasing wear on disc as well as noise of hammering.

Side hub and disc-stop are made up with tapered joints to overcome the tendency to leak at these places.

Regrinding is a very simple operation and requires but a few minutes.

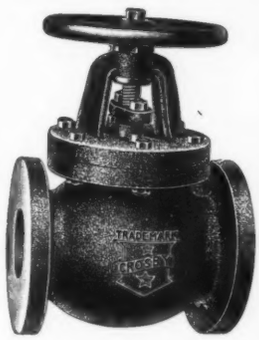
Made in sizes up to 3 inch, screwed or flanged.

CRANE CO.,

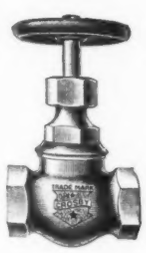
CHICAGO.

ESTABLISHED 1855.

The Spring Seat of the Crosby Valve



TRADE MARK CROSBY prevents jamming when the valve is closed and accommodates any variation of temperature.



We make these valves in either iron or brass, globe and angle styles for high or low pressure, and for superheated steam.

Ask for the Catalog.

Crosby Steam Gage & Valve Co.

Boston. New York. Chicago. London.

Would You Trade A Good Dollar For A Dollar With A Hole In It ?

Unless you were perfectly willing to get the worst of the deal, you certainly would not. It's exactly the same way when you engineers and power plant men turn over your good money for poor valves and pipage equipment.

You are getting "something" with a "hole" in it !

We call your attention to the unimpeachable products made by us. Products without a flaw—sound clear through.

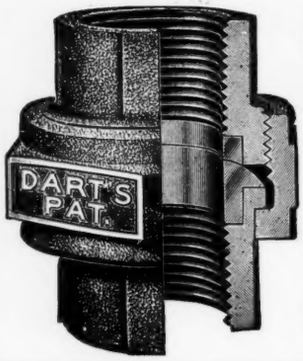
Valves, Tuyeres, Tuyere Cocks, Traps, Regulators, etc., etc.

Send for Catalogue.

PITTSBURGH VALVE, FOUNDRY AND CONSTRUCTION COMPANY

PITTSBURGH NEW YORK BOSTON
CLEVELAND BIRMINGHAM, ALA.

Non-Corrosive Seats



of bronze ball ground and snugly fitted into a powerful iron body.

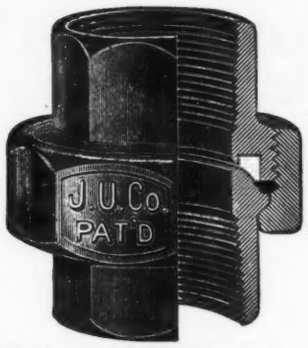
DART UNIONS

require no packing, are perfectly tight and easily opened or replaced.

Write for our Booklet.

E. M. Dart Mfg. Co.,
Providence, R. I.

Used Over And Over

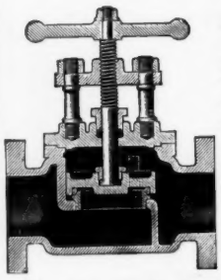


The Jefferson Union is designed for repeated use. Neither washers, packing nor gaskets are required and a *"never-leak joint"* is guaranteed under the highest pressures of steam, water, gas or air.

Write for Catalog.

The Jefferson Union Company,
31-37 Fletcher St., Lexington, Mass.

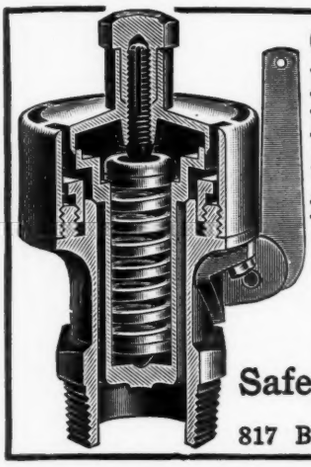
"BELLVILLE VALVES"



have the seat on the outside of an inverted cone where the direct current of steam does not come in contact with it, preventing all chance of wire drawing. Other features in catalog.

Heavy, Compact, Durable,
no marring by pipe tongs.

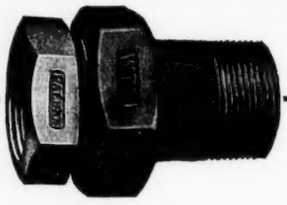
Eastwood Wire Manufacturing Co.,
BELLEVILLE, NEW JERSEY.



Over 600,000 of Kunkle's Patent Lock-up Pop Safety Valves now in actual use.

For Portable, Stationary, Locomotive and Marine Boilers. They meet every requirement. We also make Mufflers for Locomotives. Write for details and prices.

Fort Wayne Safety Valve Works,
E. B. Kunkle & Co.,
817 Barr St., Fort Wayne, Ind.



Use "Kewanee" Unions

Male and Female Pattern

Get "Kewanee" Male and Female Unions, instead of the ordinary malleable unions, and, (using 1¼" unions as the basis of comparison),

You'll Save 16 Cents On Each Joint

That's because of the saving in time and labor of installation. For you'll need no nipples, no gaskets, fewer joints, fewer connections, etc.

"Kewanee" Unions are tested under AIR pressure. They have ball-joint seats, brass-to-iron contact, and brass-to-iron thread connection. They never rust—never leak.

Send for proof that they save 16 cents on each joint.

National Tube Company,
Pittsburg, Pa.

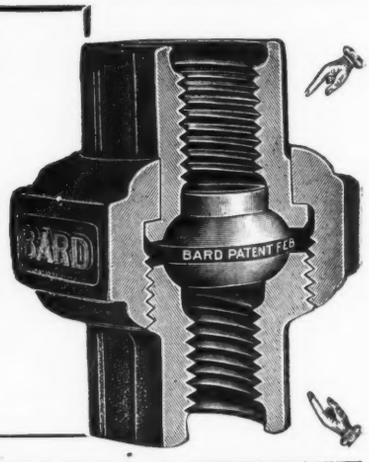
District Sales Offices:

New York	Pittsburg	Philadelphia	Chicago	Denver	New Orleans
St. Louis	San Francisco	Portland	Atlanta	Salt Lake City	Seattle

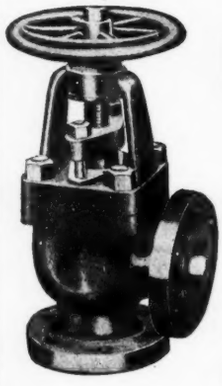
EFFECTUALLY STOPPED

When you join pipes with a Bard Union they hold as securely as one solid pipe as long as you like.

Notice the recessed ends.



The Bard Union Co.,
Incorporated,
Norwich, Conn.



Manufacturers of the

EDWARD VALVE

For High Pressures, Superheated Steam and Water.

THE LAMMERT & MANN
Oil Dash Pots for Corliss Engines, Gas and Gasoline Engines.

LAMMERT & MANN,
ENGINEERS and MACHINISTS,
157 S. Jefferson St. CHICAGO, ILL.

COLLIN

STEAM PRESSURE REGULATING VALVE

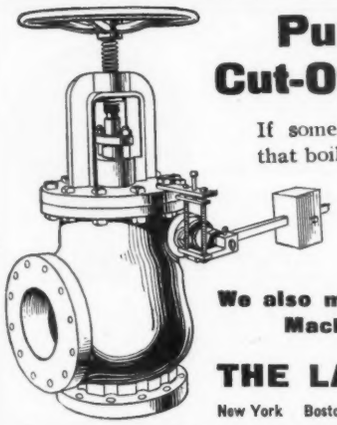
SIMPLE, DURABLE AND DEPENDABLE.

Insures Continuous Perfect Regulation.

Write To-day for Booklet P-B.

THE OHIO BRASS COMPANY, Mansfield, O., U.S.A.

32 Cortlandt St., New York. : 277 Dearborn St., Chicago. : 138 Front St., San Francisco.



Put a Lagonda Automatic Cut-Off Valve on Every Boiler

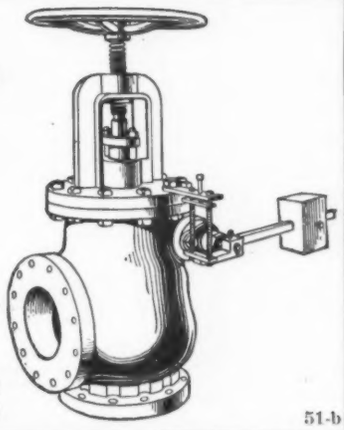
If something happens to one boiler it automatically shuts off that boiler, while the others go on supplying steam. If anything happens to the mains or the engine, it shuts off all the boilers so that escaping steam cannot injure the power house or the men.

WRITE FOR SPECIAL CATALOG.

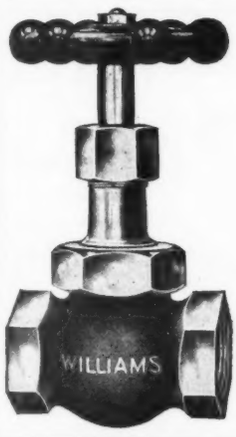
We also make Weinland Tube Cleaners, Lagonda Reseating Machines, and the Lagonda Boiler Tube Cutter.

THE LAGONDA MFG. CO., Springfield, O.

New York Boston Philadelphia Pittsburg Chicago Toledo St. Paul San Francisco London



51-b



Let The Williams Valve Prove Its Worth To You!

THE BEST WAY to determine the value of a Williams valve is to *try it*. Try it in places where other valves won't stay tight—in other words give it the most severe test you can think of.

You will find the Williams valve particularly strong at any pressure up to 200 pounds and on account of its high-lifting disc and large seat opening, friction is reduced to a minimum.

Can Be Repacked Under Pressure.

One feature of the Williams valve, that appeals to every engineer is the fact that it *can be repacked* under full pressure of steam or liquids, without any danger of the operator being burnt or scalded. This is easily and quickly accomplished by simply having the valve wide open.

There are many other good points in the Williams which you will like—if you only try one.

Write—WILLIAMS on your next order.

THE D. T. WILLIAMS VALVE COMPANY,

904-910 BROADWAY, - - - CINCINNATI, OHIO.

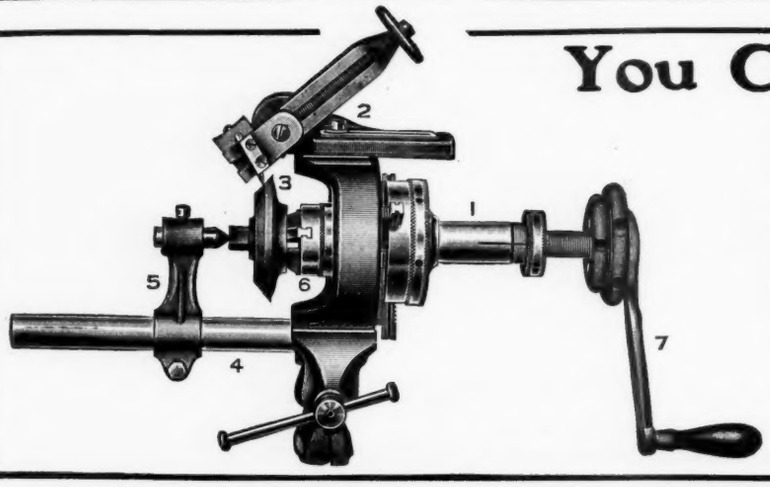
The Whale Trade Mark Means Safety

It is not how much money you put into a valve that counts, but the difference between that and the amount you take out. There's a larger marginal profit to be had from New Bedford Valves than from any other kind regardless of price. *Write.*

NEW BEDFORD BOILER & MACHINE CO.,

Established 1872,

NEW BEDFORD, MASSACHUSETTS.



You Can Prove It

At our risK, that a Dexter Valve Reseating Machine will keep your valves perfectly tight.

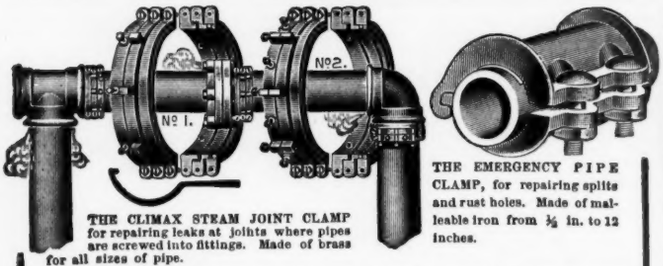
You can have a machine 30 days, use it all you care to and then return it at our expense if you do not want it.

You can save a good share of its cost in reseating your leaky valves on the pipe line, and reclaiming those old valves that are lying around now useless.

Why not do it now?

Send for Catalog P illustrating these machines.

The Leavitt Machine Co.,
Orange, Mass., U. S. A.



THE CLIMAX STEAM JOINT CLAMP for repairing leaks at joints where pipes are screwed into fittings. Made of brass for all sizes of pipe.

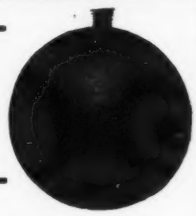
THE EMERGENCY PIPE CLAMP, for repairing splits and rust holes. Made of malleable iron from ⅛ in. to 12 inches.

PIPE REPAIRS FOR ANY CONDITION

Send for Catalog of
STEAM SPECIALTIES

JAMES McCREA & CO.,
MANUFACTURERS,
61 West Washington Street, Chicago.

HERCULES SEAMLESS COPPER FLOATS



OVER 240,000 IN USE

To be sure they cost a trifle more than others, but they're **WORTH a great deal more.** In quality, strength, durability and fine workmanship they have no equal. We fully guarantee 'em under all pressures. Catalog "B"?

HERCULES FLOAT WORKS, P. O. Box 396, **Springfield, Mass.**

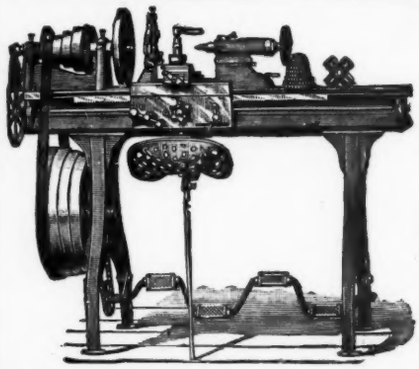
Threading an 8-inch Pipe Bend with a No. 3 "Toledo."

Why "TOLEDO" Pipe Threading Devices are constantly growing in favor.

1—They thread pipe easier than others.
2—They are light and therefore portable.
3—They are mechanically right.
4—They are the essence of simplicity.
5—They are strong and of the best obtainable materials.
6—They are inexpensive as compared with other tools not so good.
7—They are furnished with a set of dies for each size pipe, thus giving many times more die service than tools, using one set of dies for several sizes.
8—The dies are simple, and do not require a diemaker to keep them in good condition.
9—The dies are less expensive than others.
10—There are over 30,000 satisfied users.

Write us and we'll tell you more about them.

THE TOLEDO PIPE THREADING MACHINE CO.,
TOLEDO, OHIO.



TRADE W. & J. B. MARK

Foot Power Lathes

For electrical and experimental work, gunsmiths, and tool makers, general machine shop work, bicycle repair work.

The Best Foot Power Lathes Made

Catalog Free.

W. F. & John Barnes Co., 990 Ruby Street, ROCKFORD, ILL.

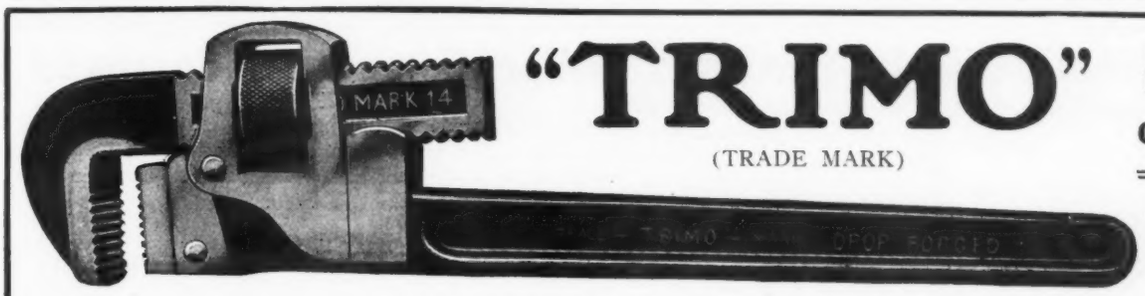
STARRETT TOOLS ARE STANDARD

Lasting Satisfaction

There is a LASTING SATISFACTION about using the best tools made—satisfaction to you—satisfaction to those who use the product of your labors.

Ask for Catalog No. 18AG—the catalog of "lasting satisfaction" tools.

THE L. S. STARRETT COMPANY,
ATHOL, MASS., U. S. A.



"TRIMO"

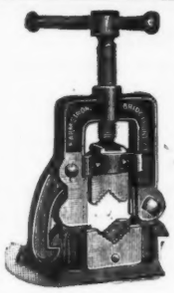
(TRADE MARK)

Our Past Record Is Your Guarantee

Send for our Catalog No. 21.

We want every user of Pipe Wrenches to give the "TRIMO" a trial. Superior in strength, working qualities, and ability to stand up under hard service. The Interchangeable Jaw in the handle adds 50% to the life of the wrench.

TRIMONT MANUFACTURING COMPANY, 55-71 Amory Street, ROXBURY, MASS.



Hinged Pipe Vises

Made in 4 Sizes

Ranging from 0 to 6 inches

Catalog on Request

Manufactured by

The Armstrong Mfg. Co.

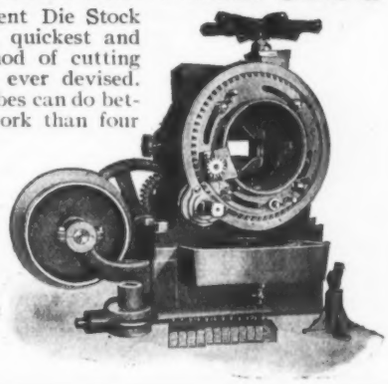
Bridgeport, Conn.

287 Knowlton, St.

This Mark Means the Genuine

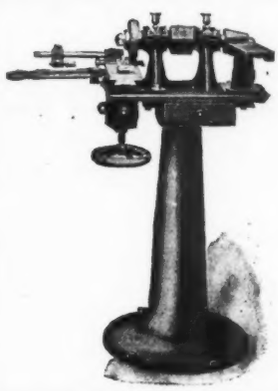
GEARS PROTECTED FROM CHIPS

The Forbes Patent Die Stock affords the simplest, quickest and most accurate method of cutting and threading pipe ever devised. One man with a Forbes can do better, quicker, larger work than four men with an old fashioned die stock.



WRITE

THE CURTIS & CURTIS COMPANY, 85 Garden St., Bridgeport, Conn.



DEBUT

It is needless to say that steel pipe requires a sharp, properly shaped die to produce good threads. The little machine shown here is the

B. & K. DIE GRINDER

for the correct grinding of the dies. Simple to operate, modern in price, and will save you dollars. Shall we send description ?

BIGNALL & KEELER MFG. CO.

EDWARDSVILLE, ILL.

WITH AN

"AGRIPPA"

YOU'VE GOT 'EM ALL "CINCHED"

Agrippa's feature of a single jaw is not alone "Happy Jack" on straight pipe work but it's without an equal on the "all-around" game; short nipples, fittings of all kinds with irregular angles and small surfaces for wrench to catch upon are meat for "Agrippas." One tool only for regular and "cranky" work and quickest in making pipe, etc., adjustments. Discount and free trial from dealer. Made by pioneers in Chain Pipe Tools.

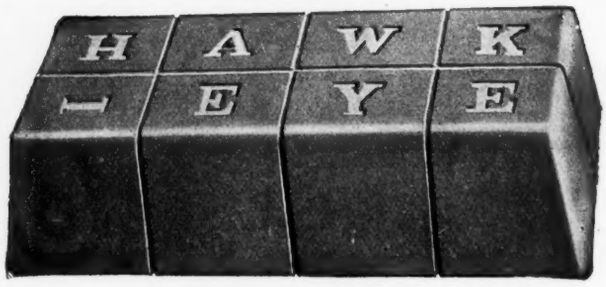
J. H. WILLIAMS & CO.

SUPERIOR DROP-FORGINGS

BROOKLYN, N. Y. CITY

The Hawk-Eye Is The Only Boiler Compound Company

All other firms deal in other articles.



Eight one-pound squares in every block.
There is no acid in our compounds.

If a physician attempted to plead a law case in court he would be called a Jack of all trades and those who are engaged in all kinds of business and at the same time attempt to manufacture boiler compounds are Jacks of all trades and Masters of none.

After you have grown tired of spending money with that class, send us an order and you will not regret it.

Hawk-Eye Compound Company
303-304-305 Merrick Block, CHICAGO, ILL.
'PHONE WENTWORTH 135

DODGE MANFG. CO., **MISHAWAKA. IND.**
Manufacturers of
Highest Grade Diamond D
Power Transmission Machinery and
Eureka Water Softening and Purifying Apparatus.

The BLACKBURN SMITH
Feed Water Filter and Grease Extractor
removes oil and other suspended impurities from feed water by means of *double* filtration through layers of terry cloth. No other filter is so easy to clean and so thorough in action.
Write for free book on *"Feed Water Filtration."*
JAMES BEGGS & CO., 106 Liberty St., New York

PURE WATER FOR THE BOILERS BY THE
WE-FU-GO and SCAIFE
Water Softening and Purifying Systems.
RESULTS GUARANTEED SEND FOR OUR CATALOG.
WM. B. SCAIFE & SONS CO.,
Founded 1802. PITTSBURG, PA.

EVERY STEAM PLANT SHOULD HAVE ONE
What? Why a Peerless Grease Extractor to eliminate all danger and waste of money due to grease-bearing steam. 'Twill pay its cost over and over. *Booklet?*
HUSSEY, McCANN & CO.,
87 Warren St., New York.

BIRD-ARCHER BOILER COMPOUNDS

BIRD-ARCHER COMPOUNDS are the best possible boiler protection because they are made up specially for each case and recommended only after careful feed water analysis by experienced specialists.

If you have used BIRD-ARCHER COMPOUNDS you know that they are always good and reliable. You know that they are exactly adapted to their work and have virtues not found in other compounds.

Don't risk your boilers and make trouble for yourself by trying some inferior substitute.

Write for our book, "Ten Questions for Steam Boiler Users."

The Bird-Archer Co.,
90 West Street, New York City.

1876—1908

The Fidelity and Casualty Co. Of New York.

George F. Seward, President. Robert J. Hillas, Vice-President and Secretary.

The Company grants insurances as follows:

FIDELITY BONDS	STEAM BOILER
EMPLOYERS' LIABILITY	ELEVATOR
PERSONAL ACCIDENT	FLY-WHEEL
HEALTH	BURGLARY

PLATE-GLASS

In the Fidelity, Boiler, Elevator, and Fly-Wheel lines careful inspections are made by experts.

Capital:	Surplus:
$1,000,000.	$1,536,189.88.

Elevator Insurance.

The owner of a passenger elevator is held to the highest degree of care that human foresight can devise for the safety of persons riding in it. Judgments have been given in favor of persons injured by elevators in very large sums, reaching as high as $30,000 in individual cases. Every elevator owner requires insurance to cover this hazard.

The Company makes careful inspections of its risks and reports to the assured any elements of danger that may exist.

Write for particulars.

THE AMERICAN PULLEY

The first, the best, the most largely sold all steel parting belt pulley.

More than 1,000,000 in use filling every condition of service in a most satisfactory manner.

Sold by Supply Houses Everywhere.

Patented in the U. S. and foreign countries.

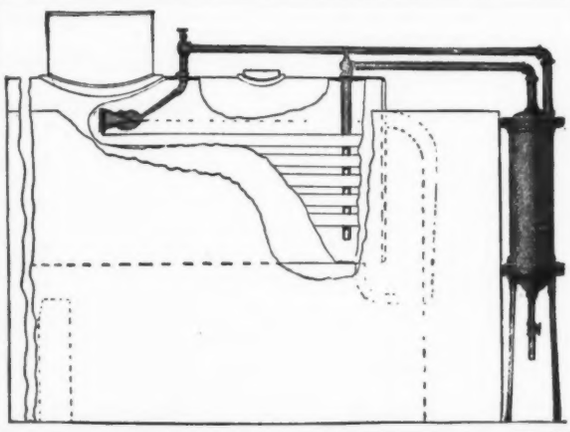
Our Booklet?

THE AMERICAN PULLEY CO.,
29th and Bristol Sts., Philadelphia, Pa.

The Akron Friction Clutch

is dust-proof, noiseless, reliable and works in an oil bath. Easily installed, adjusted and operated. Circular on request.

The Williams Foundry & Machine Co.
Akron, Ohio
Successors to the Akron Clutch Co.



We Guarantee Absolute Satisfaction And Install On Trial

The Buckeye Automatic Skimmer

Could any proposition be fairer? It will keep your boiler scale free without taking any of your time.

Anyway get our catalog?

Buckeye Boiler Skimmer Company,
South End, Toledo, Ohio.

DISSOLVES THE OLD SCALE

no matter how thick—saving countless times its cost in fuel, trouble and repairs.

Send A Sample of your Scale For Analysis.

PURE WATER FOR THE BOILER

will insure freedom from scale in future, and Pyramid Compound will insure pure water.

Binghamton Boiler Compound Co.

WATER PURIFYING CHEMICALS,
BINGHAMTON, NEW YORK, U. S. A.

Los Angeles, Cal.; Seattle, Wash.; Portland, Oregon; Cincinnati, Ohio; Cleveland, Ohio; Providence, R. I.; Syracuse, N. Y.; Scranton, Pa.; Louisville, Ky.; St. Louis, Mo.; Birmingham, Ala.

Cling-Surface is a preservative treatment for belts and ropes, a food, which penetrates into them, making and keeping them pliable, waterproof and preserved—not sticky, prevents all drying out or cracking.

And at the same time stops all slipping so all belts or ropes can be run easy or slack and carry fullest loads.

You can't do this without Cling-Surface and we guarantee results. Write us.

Cling-Surface Company

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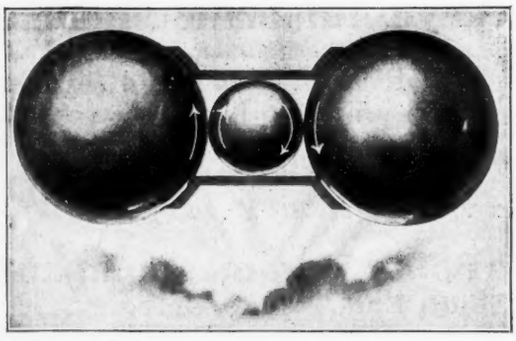
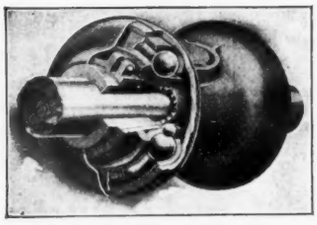
Take Out Your Ring Oiling Bearings and Install The "Chapman" We Guarantee Results





It's easy to cut down coal bills, oil bills and belting provided you awake to the true value of Chapman Double Ball Bearings and install them in your plant. They require no oil, demand no attention and will run for years and years without a thought. Your power CAN'T leak out through them—they work WITHOUT FRICTION. Cool under the heaviest loads.

Write for a Catalog.

CHAPMAN BALL BEARING CO.,
40 Bristol St., BOSTON.

This is The Philips Steel Pulley!

The face furnishes entire belt contact because it has a perfect crown.
It is true running and strong.
You may try it before you buy it.

Philips Pressed Steel Pulley Works,
351 Glenwood Ave., Philadelphia, Pa.

C-O-Two Tile
FIRE ARCHES
Any Rise, Any Span,
Air Baffle Mixing System
produces
RESULTS

C-O-TWO FURNACE COMPANY, Syracuse, N. Y.

We Increase the Driving Power of Your Belts

We can furnish unquestionable proof that, with our pulley cover, the same power you now use, can do five times as much work as an uncovered wooden pulley or ten times that of the iron pulley.

WRITE.

HERCULES PULLEY COVER CO.
Detroit, Mich.

SAVE POWER BELTING BEARINGS

If you want belts that run straight, smooth, and without noise,
If you want belts that can run slack and yet develop the most power in severe service, or in changing temperature and humidity,
If you want belts that will last nearly a lifetime without sign of weakening,
If you would cut down your yearly belting expense,
If a power saving of from 25% to 33 1-3% looks good to you,

SHULTZ SABLE RAWHIDE BELTING
will fulfill your requirements.

Get a SHULTZ SABLE RAWHIDE BELT for 60 days free.

SHULTZ BELTING CO.
ST. LOUIS, MO.

NEW YORK, 111 Chambers St. BOSTON, 114 High St. PHILADELPHIA, 116 N. 3rd St.

No. 27

Robins Laminated Leather Belting

Eliminates The Glue Pot

SOLVES THE BELT PROBLEM.

The Scientific Principle:

Continuous strands are spirally cut from the choicest leather locations of the belting butt to exact mechanical gauge. The strands are then separately stretched to the extreme elastic limit and assembled on edge forming a belt of any practical length, width or thickness. Made endless on pulleys with a simple interlocking splice.

The Positive Result:

A continuous belt without laps, plies or cement. Absolute uniformity of strength, gauge, balance and flexibility. Complete adjustment to varying pulley conditions with the maximum of surface and circumferential contact. Remarkable power transmission and highest productive efficiency.

Write for Circular No. 2 giving detailed description.

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We are publishing the best books for engineers—we handle all books of all publishers. When you get up against a knotty question, write us and if there is a good book to help you out, we can supply it.

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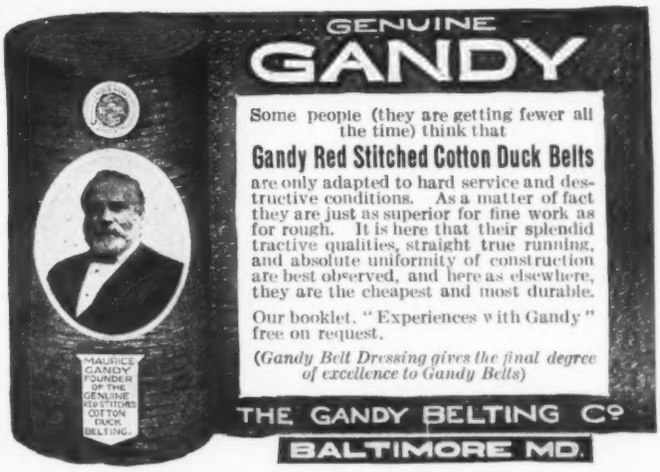
GENUINE
GANDY
Some people (they are getting fewer all the time) think that
Gandy Red Stitched Cotton Duck Belts
are only adapted to hard service and destructive conditions. As a matter of fact they are just as superior for fine work as for rough. It is here that their splendid tractive qualities, straight true running, and absolute uniformity of construction are best observed, and here as elsewhere, they are the cheapest and most durable.
Our booklet, "Experiences with Gandy" free on request.
(Gandy Belt Dressing gives the final degree of excellence to Gandy Belts)
MAURICE GANDY FOUNDER OF THE GENUINE RED STITCHED COTTON DUCK BELTING.
THE GANDY BELTING Co
BALTIMORE MD.

BELT HEALTH

is as much dependant on cleanliness as is yours and mine. Belts that have been **doped** for years with gummy, sticky nostrums are **sick,** and **can't** do a good day's work no matter how hard you try to make them. There's no life in them, no **grip,** they are **thick** and **heavy,** and the only remedy is

OXoilOX

nature's belt food, made from the hoofs of cattle. It drives out this old gummy stuff; leaves the belts soft, tough, and clean. Then they **have** life and health. They cling so closely to pulleys that all air is excluded and the vacuum thus formed enables a belt to run slack at its full capacity without slipping. Start **new** and **right** with **OXoilOX.**

FREE

F. S. WALTON CO., Philadelphia, Pa. Gentlemen: Kindly send us, free of all charge, a sample can of OXoilOX, the perfect belt dressing.

NAME ..... NAME OF FIRM .....

ADDRESS .....

NUMBER OF BELTS ..... AVERAGE SIZE .....

F. S. WALTON CO. Pressers and Refiners of all grades of Neatsfoot Oil. PHILADELPHIA, PA.

"Edge-on" LEATHER BELTING

PATENT LAMINATED BELT * CEMENTLESS LAPLESS ENDLESS * C CAN'T FAIL F A

U. S. Patent Dec. 3, 1907

PATENT LAMINATED BELT * CEMENTLESS LAPLESS ENDLESS * C CAN'T FAIL F A

U. S. Patent Dec. 3, 1907

Note the Difference in Pliability Between "Edge=on" and Cemented Belting

The illustration shows how the same pressure that will bring the ends of a piece of "Edge-on" together only makes a "horse shoe" of cemented belting. And this shows very clearly the superior pliabiltiy and flexibility of "Edge-on."

An entirely new principle is employed in making this laminated belting. It is made of strips, each one a single piece sewn through and through across their width, and no cemented joints are used. Thus "Edge-on" has a natural curve to fit the pulley, which prevents the outside from stretching and the inside from crowding, and which increases the friction 50%.

"Edge-on" is more durable, more capable of pulling heavy loads, and has greater cohesion than any other belting made. If you are having trouble with your power transmission problems, "Edge-on" offers you a certain and immediate solution.

LAMINATED BELTING COMPANY,

Chicago Branch, 44-46 Franklin St. **51 BEEKMAN STREET, NEW YORK CITY.**

Rhoads Leather Belting

saves time waste. It is built for service,—continuous service on the long run. Its strength, trueness, and the fact that it is thoroughly and permanently stretched get this result. It does the work and keeps doing it.

J. E. RHOADS & SONS

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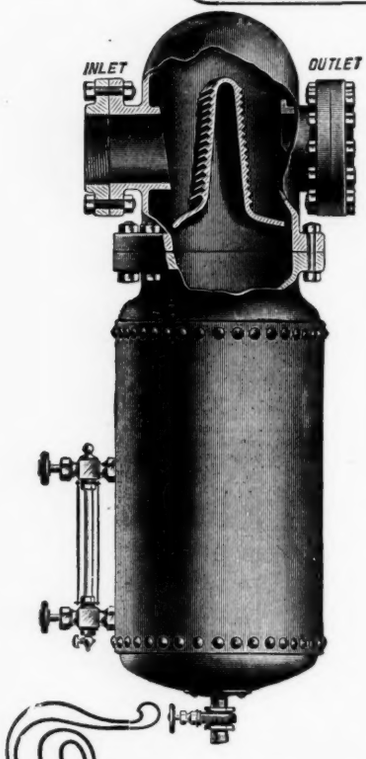
NEW YORK: 40 Fulton Street
BOSTON: 105-111 Summer Street
Hamblet & Hayes Co., Eastern Agents

Factory and Tannery, Wilmington, Delaware



The Austin
Figure "L" Horizontal
STEAM SEPARATOR

Cast "Head" with large steel shell Receiver or Accumulator. Designed for High Pressure Service.

Makes Wet Steam Dry.
Prevents Cylinder Explosions.

Guaranteed to separate the moisture from live steam maintaining a steady flow of DRY STEAM to the ENGINE CYLINDERS regardless of variation of load.

We ship on trial.
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AUSTIN SEPARATOR CO.
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One 50 H.P. Amsler Gas Producer, located at Birmingham, Alabama.

One 250 H.P. Amsler Gas Producer, located at Oil City, Pa.

Both producers have never been used and are absolutely new.

A bargain to any one who is in need of an economical power generating plant.

W. O. Amsler & A. C. Davis
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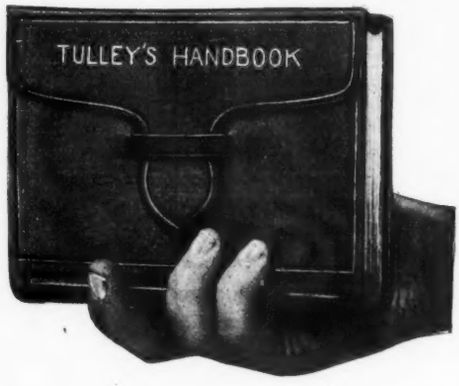

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Tulley's Handbook enjoys the reputation of being the best book for steam and electrical engineers ever published. There are over 1000 pages, of practical information, covering every phase of power plant engineering. Don't fail to send for the FREE booklet today. One minute and a postal are all that are required. Ask for booklet A.

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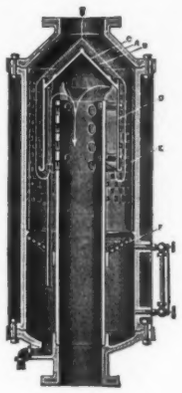
SUFFICIENT SEPARATING SURFACE

Without the least danger of back pressure **Sweet's Steam Separator** extracts from your steam all except ½ of 1% of the condensation water and **keeps it separate.**



As an oil separator it removes 99% of the oil from exhaust steam. *Ask for descriptive catalog.*

Ample space for Steam Storage.

DIRECT SEPARATOR COMPANY,
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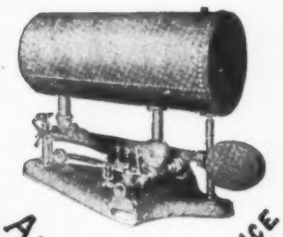
SYRACUSE, NEW YORK.

MOREHEAD



ALWAYS IN SERVICE

YOU CAN SEE IT WORK

All working parts are on the outside. Watch it! When sufficient water enters, the trap automatically tilts downward. Gravity does it. We illustrate a No. 2 Morehead Vacuum Trap that has for the past eight years been in operation at Stott's Mill, Detroit, Michigan.

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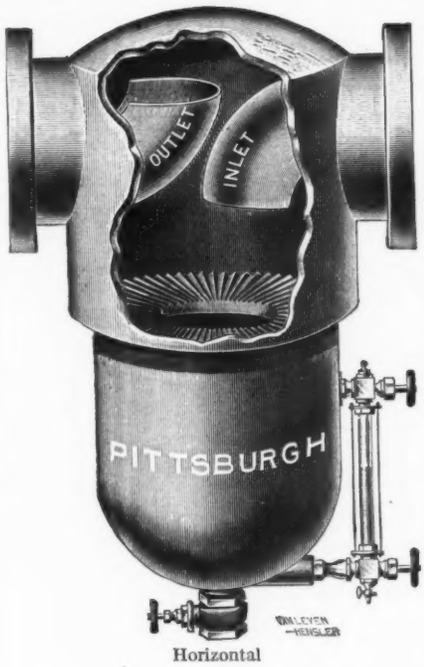
Morehead Manufacturing Co.,
1051 Grand River Ave., DETROIT, MICH.

"Pittsburgh" Steam Separators



Horizontal

For Live or Exhaust Steam

Utterly Simple **Perfectly Effective**

Highest Efficiency—
Proved by Laboratory Tests.

No Baffle Plates—
To Cause Spattering Back.

No Contracted Areas—
To Retard Freedom of Flow.

No Small Passages—
To Foul and Clog.

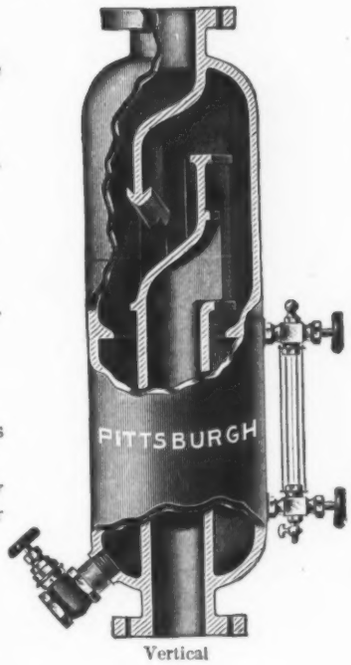
Perfect separation secured by sudden changes in direction of steam flow.

Separated water and oil drained directly away from steam current and into protected receiver space.

Horizontal and Vertical Types

Plain and Receiver Styles

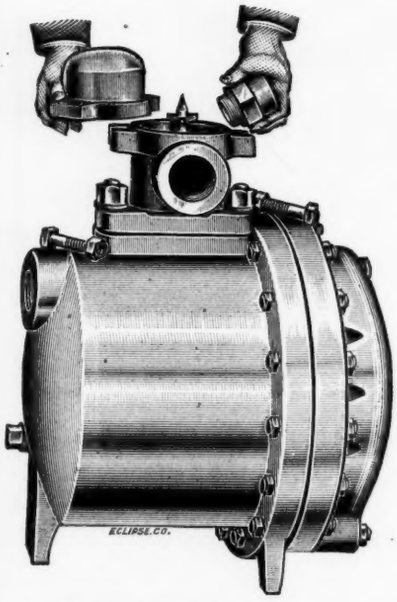
Made in all sizes—Shipped on Guarantee Trial.



Vertical

Pittsburgh Gage & Supply Co., Pittsburgh, Pa.

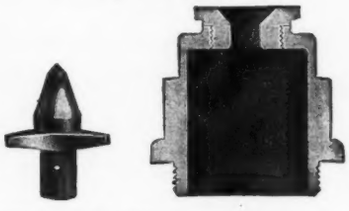
STEAM 4/S TRAPS



Inspecting the Valve and Seat

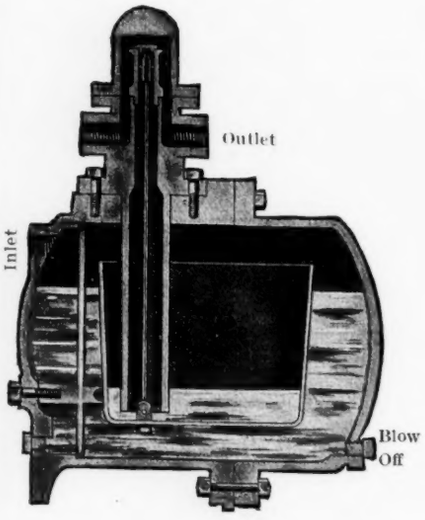
The valve and seat are placed in the very top of the trap above all scale and sediment. The action is intermittent thus reducing wire drawing of the valve to a minimum. All traps are made extra heavy and tested at 600 pounds hydrostatic pressure. Traps are made in sizes ½" to 2½" and have a capacity of 300 to 20000 pounds of water per hour, figured at a safe reserve.

Valve and Seat



The Only Wearing Parts.

See sectional view for construction of trap —Note the open cast iron bucket connected by one straight rod to the valve, the leverage used to open the valve without levers or toggles.



Every Tap is guaranteed to give satisfaction.

Write for our Catalog "A-16."

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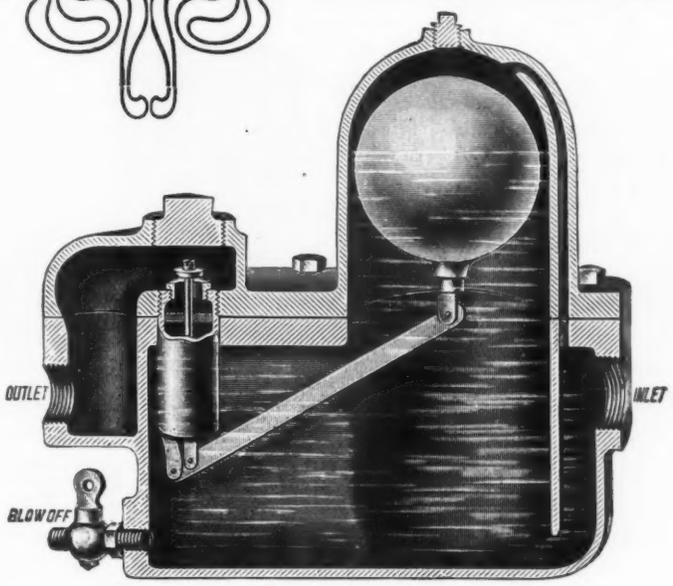

The Wright "VICTOR" Steam Trap

A Continual Flow Trap of Great Capacity for Low Pressure Steam Systems.

Operates Automatically. Keeps the Steam Lines and all connections constantly drained of accumulating condensation regardless of small flows or floods and without steam waste in the course of operation. Operates under "No pressure" or up to "Twenty Pounds."

We will ship this trap to responsible parties subject to 30 days' trial and return to us at our expense of transportation both ways if results are not satisfactory.

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WRIGHT MANUFACTURING CO.

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BAUM SEPARATORS

ARE BEST for Live and Exhaust Steam.

Positively Guaranteed.

"I take pleasure in stating that this department has used the Baum Separators for a considerable time, and has found them to be all you claim for them and are satisfactory in every respect."—The Superintendent of Public Buildings, Albany, N. Y.

Send for new Catalogue and prices.

Hershey Machine & Foundry Co.

85 Water Street, Boston, Mass.
MANHEIM PA., U. S. A.

W. G. Ruggles Co., 54 High St., Boston, Mass.
R. D. Bliss, 40 Dearborn St., Chicago, Ill.

Ten Features In the Lead of Any Other Trap

Let us prove our claims by sending a Dunham Trap on trial.

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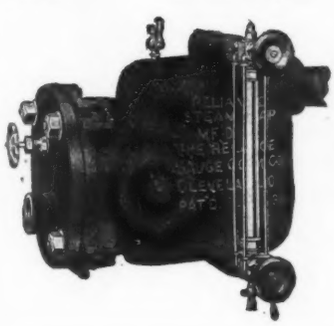
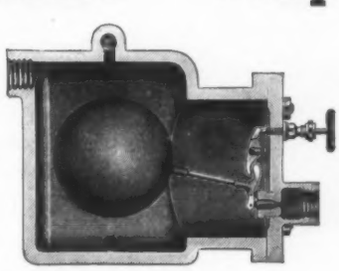
Set Then Forget The Reliance Trap

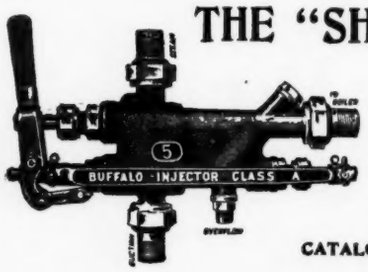


It will not require any more of your attention after the first adjustment and it can be depended upon to continually discharge all the condensation without loss of steam.



The Reliance Gauge Column Company,

75 E. Prospect St., Cleveland, Ohio.



THE "SHERWOOD" INJECTOR

Injectors, Ejectors, Gauge Cocks, Boiler Tube Cleaners, Flue Scrapers and Blowers, Oil Cups and Pumps, Lubricators, Automatic Oil Pumps, Grease Cups, Special Brass Work.

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SHERWOOD MANUFACTURING CO.,
BUFFALO, N. Y.
Manufacturers of Engine and Boiler Supplies.

THE "HART" OIL PUMP

Anderson's Improved Steam Trap

Composed of a body of close grained iron, a valve and valve seat of phosphor bronze.

The design provides for the removal of all internal parts by taking off the cap, no pipe connections need be broken.

Always locked with three inches of water to hold back the steam.

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A GOOD ONE

THE GEIPEL STEAM TRAP

is simple, efficient and economical, works equally well with high or low pressure steam and in any position.

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Nason Steam Traps

"SIDELUG" TRAP
(Patented)

THE STANDARD FOR SIXTY YEARS!

Adapted for all conditions requiring the removal of condensation without loss of steam.

SPECIFY:
"CLASS B"—For pressures under 20 lbs.
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"SIDELUG"—For pressures higher than 40 to 150 lbs.

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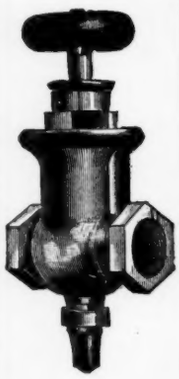

LOOK FOR "CURTIS" On Your Engineering Specialties

It is your protection against poor goods and poor service—see that you get it.

Balanced Steam Trap
Return Steam Trap
Expansion Trap
Separator
Damper Regulator
Temperature Regulator
Improved Pressure Regulator
Tank Governor and Pump

These and other specialties described in our catalogue. Write for a copy.

JULIAN D'ESTE COMPANY
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3 Pints of Oil in 28 Days

Latest **Improved**

ROCHESTER

Automatic **Lubricators**

result in a great saving of oil. This is proved by the fact that a three-pint "Rochester" on a certain marine engine was only filled once on an almost continuous run of 28 days.

Our lubricators can save oil for you. Do you think it is worth while to investigate?

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More Detroits Are Sold Than All Other Makes Combined.

That's a mighty strong claim but we can back it.

It proves the trust and confidence Engine Builders and Users place in the Detroit Lubricator.

Get what you ask for, *but ask for a "Detroit."* We'll send you one on a 20 days' trial offer.

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Detroit Lubricator Co.,
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NEW MODEL "M"

Richardson Sight Feed Oil Pump

To those interested in the details of construction, a story about the kind of material used and the valuable improvements incorporated, will be found in bulletin No. 109. May we send you one?

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Sight Feed Oil Pump Co.,
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Re-refine Your Oil

for 30 days free of cost by sending for

The Acme Oil Filter

on trial. It will turn out more clear lubricant for every gallon of dirty oil than any other filter.

Write to-day!

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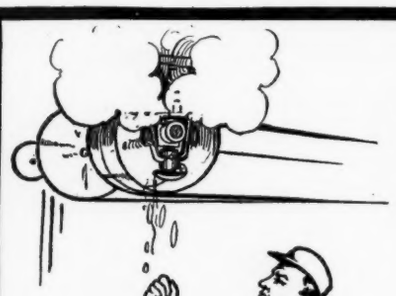

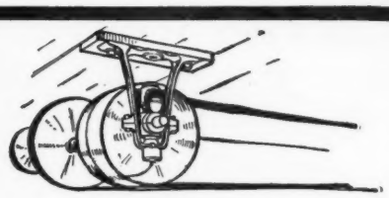

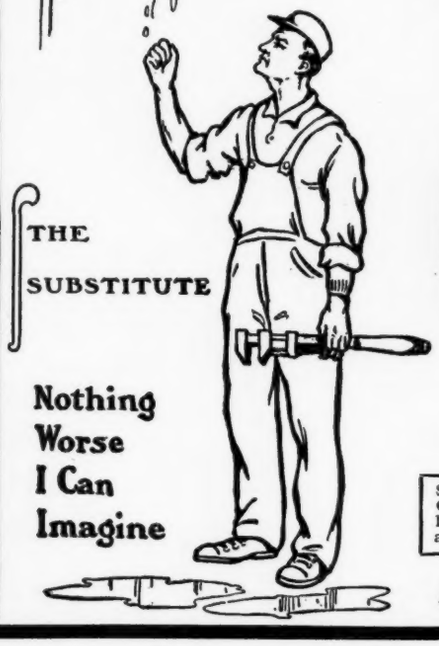

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The only Genuine ALBANY GREASE has this trade mark on every package. Look and ask for it.

Send for FREE sample cup and can of "Albany Grease," giving size of tap for cup, depth of oil hole from top of cap to journal, where to be used and firm's name.

MADE ONLY BY
ADAM COOK'S SONS,
313 WEST ST., NEW YORK.

NOTHING EASIER I SEE

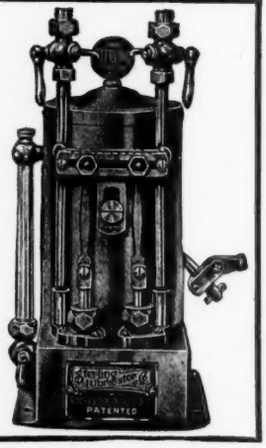
THE ONLY GENUINE

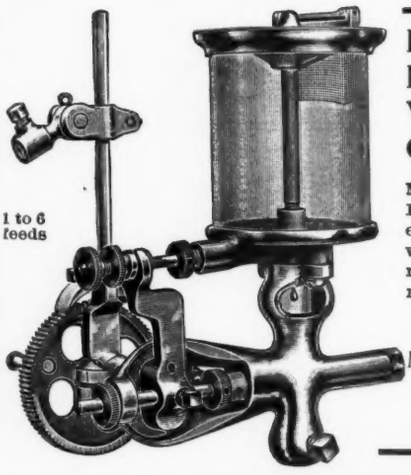
Don't Hesitate But Lubricate

Get a Sterling Force Feed Lubricator *now*, and save 40% to 60% of your oil, at the same time securing far more efficient lubrication. The Sterling pumps the desired amount of oil to the right place, and allows no waste.

CATALOG ?

Sterling Lubricator Co.
3 Frank St., Rochester, N. Y.





1 to 6 feeds

Liberal Lubrication Without Loss Of Oil

Manzel's Force and Sight Feed Lubricator delivers every drop of oil where it will do the most good and never deposits a drop too much or too little.

Booklet ?

MANZEL BROS. CO.,
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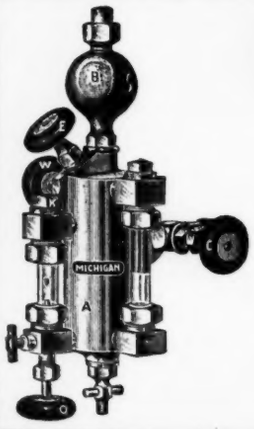

Michigan Lubricators

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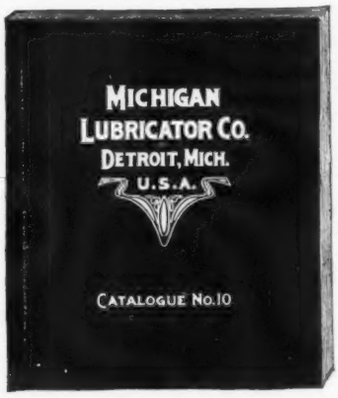
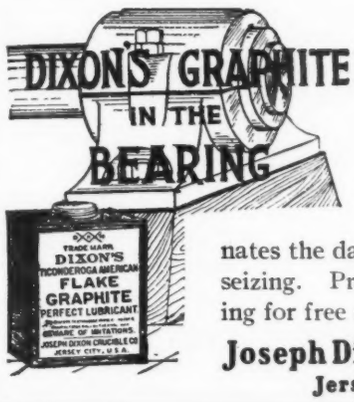
MICHIGAN LUBRICATOR COMPANY
DETROIT, MICHIGAN





This absolutely pure lubricant is the most perfect friction reducer known. It prevents excessive wear in any bearings and eliminates the dangers of cutting and seizing. Prove its merit by sending for free sample can No. 94-C.

Joseph Dixon Crucible Co.
Jersey City, N. J.

HARRIS

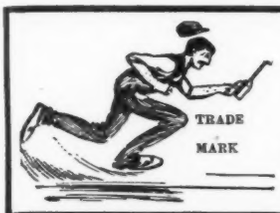
TRADE MARK REGISTERED

OILS

FOR ICE MACHINE CYLINDERS

High flash test. Low cold test and on account of its purity will neither color or impart any odor to the ice. Has excellent lubricating qualities and a small amount will properly lubricate. Barrel packages sent on approval.

A. W. HARRIS OIL CO., 323 So. Water St., Providence, R. I.



Send for
Nugent's Valuable Treatise on
HOW TO OIL AN ENGINE
and large catalog No. 7 A of new and
Up-to-date Oiling Devices for Hot Members

WM. W. NUGENT & CO.
18-30 W. Randolph St., Chicago, U. S. A.
Rimington Bros., Carlisle, England, Agents.

Taylor's Spiral Riveted Steel Pressure Pipe.

Best steel pipe made for Hydraulic Purposes. 3 to 40 inches diameter.

Furnished with improved forged steel flanges or our steel bolted joints.

American Spiral Pipe Works, Main Office and Works: Chicago, Ill. Eastern Office: 50 Church St., New York.

CUT YOUR COSTS

Dry steam will do more work and cost less money. The Sterling Exhaust Head cuts costs.

CATALOG?

INCREASE YOUR OUTPUT

effective ventilation puts life into your work—Sterling Ventilators are the most effective.

STERLING BLOWER AND PIPE MFG. COMPANY, 6827 First Avenue, Hartford, Conn.
NEW YORK OFFICE, 109 LIBERTY STREET.

DOLLARS AND CENTS EFFICIENCY IS THE ONLY WAY TO JUDGE LUBRICANTS

You can pay more per pound or per gallon, and you can get oils and greases that cost less than the genuine

Non-Fluid Oils

but you CAN'T get any other lubricant which combines the full lubricating value of oil, the cleanliness and lasting properties of grease. You CAN'T get another lubricant that will keep bearings at lower temperature, that will last so long, or will save as much power.

Tell us the speed and type of your bearings and we will send sample of NON-FLUID OIL specially adapted to your work.

Originators and Sole Manufacturers,

N. Y. & N. J. LUBRICANT CO.

Department A.

14-16 Church Street, No. 0 **New York City**

'ANTI-CORROSIVE" SAVES THE PLANT

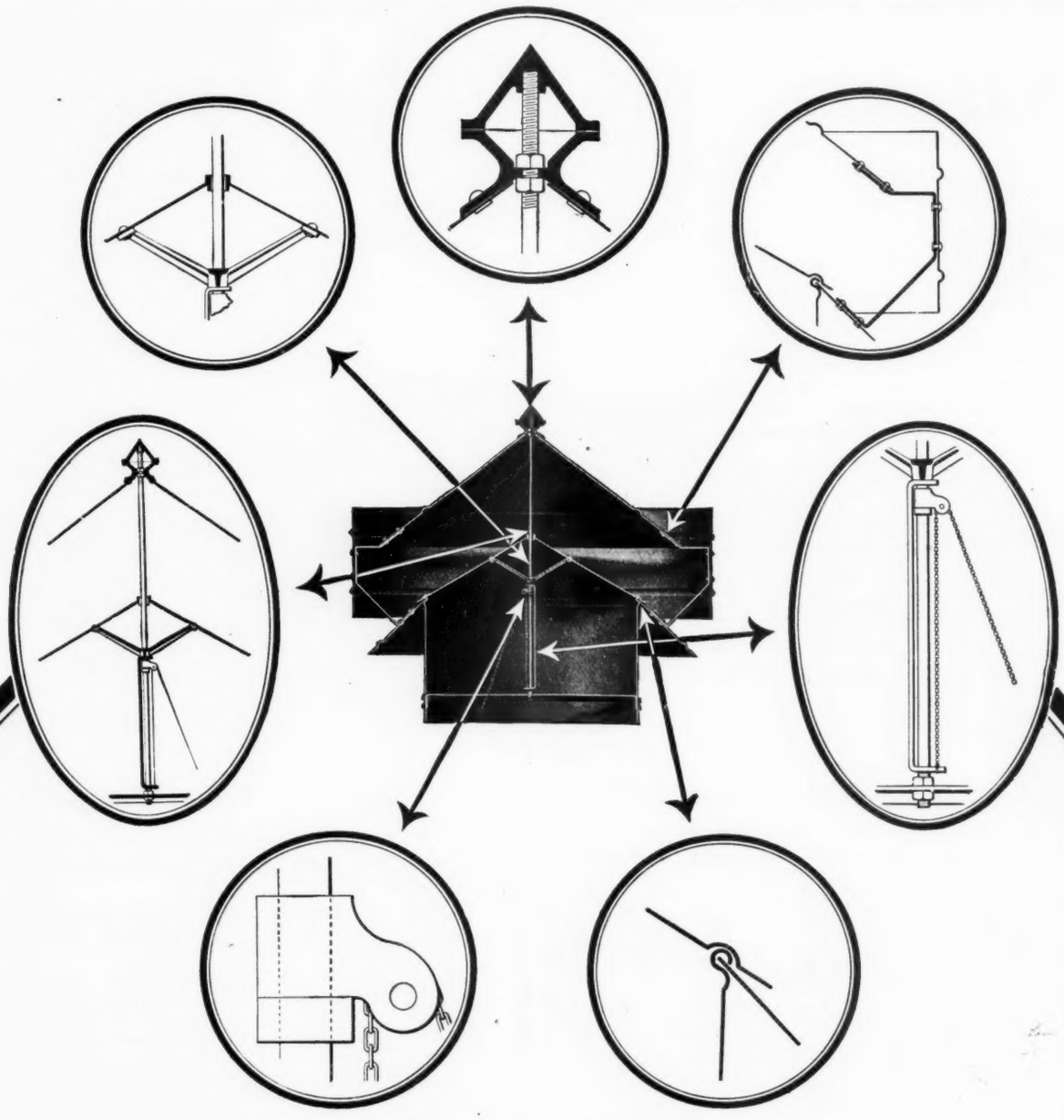
It also saves in quantity. Fifty per cent less, gives better results than any of the so-called "cheap oils." Contains no gums or acids and saves the piston packing. Reduces fuel bills and keeps the rods in first-class condition.

TRY A BARREL FOR 90 DAYS

and at the end of that time if you don't consider it well worth our price, pay us any sum you consider it worth to you. Costs a little more per gallon but a great deal less per year.

E. H. KELLOGG & COMPANY,

243 South Street, New York, N. Y.
8 B Rumford Court, Liverpool, Eng.
Established Fifty Years Ago.



IN EVERY DETAIL

"SWARTWOUT" GRAVITY CLOSING Patented VENTILATORS

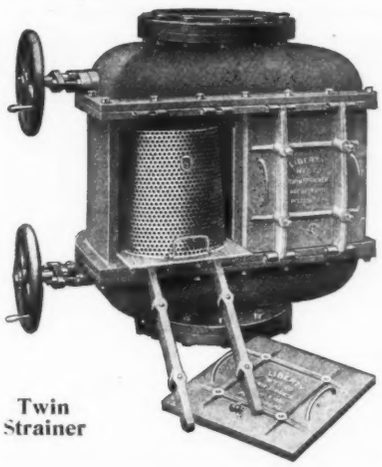
Are Designed to be the Best that High Grade Material and Workmanship Can Produce.

Study these details; the straight and stiff backbone that ties the entire construction together, the cast-iron finial made as nut and check-nut so as to draw all parts taut, the damper rigidly braced, accurately guided and close shutting, the brass pulley that won't rust in place, the rigid bracing of the weather belt, the simple guide and durable chain; these and a host of other distinctive features contribute each their share to the perfect ventilator.

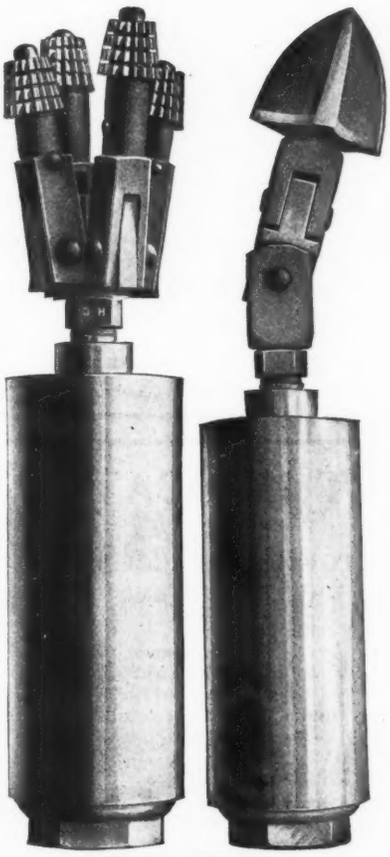
The "Swartwout" Centrifugal Cast Iron Exhaust Heads, Steam and Oil Separators are designed and built with the same thorough, painstaking care.

THE OHIO BLOWER CO., CLEVELAND, OHIO.

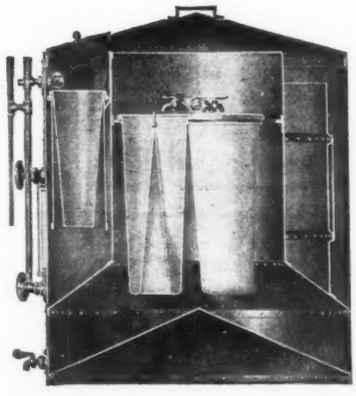
STANDARD ENGINEERING CO., Toronto, Ont., Exclusive Licensees and Manufacturers of "Swartwout" Steam Specialties for Dominion of Canada. 1-46



Twin Strainer



Turbine Cleaners



Oil Purifier

The Liberty Cleaners And What They Do.

The Liberty Heavy Duty Turbine Cleaner will clean a four-inch eighteen-foot tube containing scale one inch thick in twenty minutes.

The turbine is practically indestructible, and on a water pressure of 150 lbs. it develops over three horse power.

The Liberty Twin Strainer consists of a casing having two passage ways, each containing a basket shaped strainer removably secured and forming pockets to catch and hold the dirt in the water.

By a simple valve arrangement the water is diverted through either passage while the other is being cleaned.

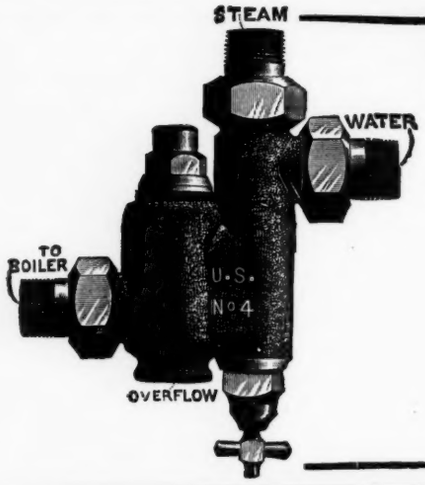
With the Liberty Oil Purifier the oil is first strained, then separated from the entrained water, then heated to a high temperature releasing the heavier impurities so that they settle to the bottom of the chamber instead of passing into and clogging up the filter bags—finally the oil is passed through the filter bags and into the clean oil chamber ready for use.

Ask for our Bulletins.

LIBERTY MANUFACTURING COMPANY,

6509 Susquehanna Street,

PITTSBURG, PA.



U. S. Automatic Injectors have an International Reputation for Superiority.

They have just as firm a foothold abroad as at home. Only genuine merit has placed the "U. S. Automatic" in this position. The more particular you are about securing reliable boiler feeding—the better it pleases us—for we have the **only reliable boiler feeder.**

Send for our Engineers' "Red Book"—it slips right into the vest pocket, small in size, but large in information.

American Injector Company,
Detroit, Michigan.

A Powerful Little Device for Elevating, Conveying and Transporting Liquids—

The Garfield Ejector

Cannot be beat for raising water from deep wells, mines or pits, filling or emptying tanks, raising or transferring liquids, etc.

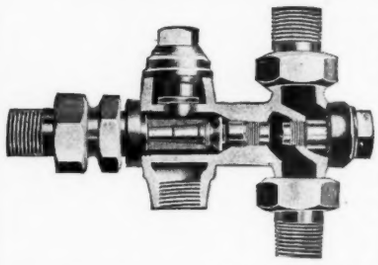
Note the straight pipe connections making it desirable for elevating water from deep driven or drilled wells.

Positive in Its Work and Nothing to Get Out of Order

You cannot afford to be without it. Write for complete description. Large Catalog sent free.

The OHIO INJECTOR CO.,
The World's Greatest Injector Manufacturers,
WADSWORTH 110 Main St. OHIO, U. S. A.

The Desmond Automatic Injector The Acme Of Simplicity



As far superior to the old style complicated Injectors as modern machinery is to that of a Generation ago.

Every one fully guaranteed. Accept no out-of-date substitute. Insist upon the DESMOND. Write for Catalog.

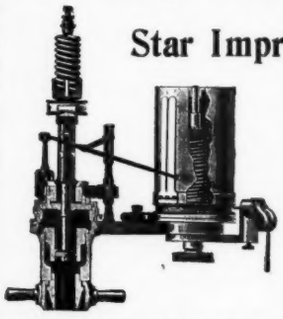
The Desmond-Stephan Mfg. Company,
Urbana, Ohio.

A PERFECT INDICATOR

IS THE

Star Improved Outside Spring

Class B Style.



Suitable for.....
High Pressures,
High Speeds,
Superheated Steam,
and all uses where absolute accuracy is required.

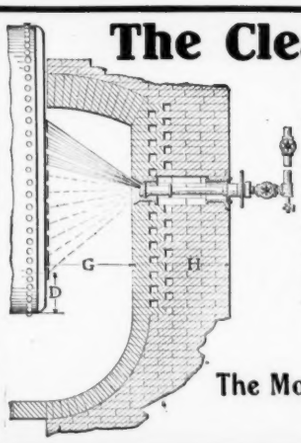
A QUALITY INSTRUMENT.

Send for Circular.

Manufactured Exclusively By

Star Brass Mfg. Co., 108-114 E. Dedham Street, **Boston, Mass.**

The Cleanest Thing



in a boiler room is the boiler after using the Monarch Steam Flue Blower. It cleans every flue and keeps 'em clean. Blows with draft from the rear of combustion chamber. Avoids all that messing about the front of the boiler to clean flues with steam hose. Saves coal? Well, some.

CATALOG?

The Monarch Steam Blower Co.
Troy, New York

Make Your Engine Talk

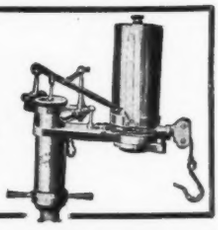
and it will keep you posted on its needs.

THE TRILL TRIUMPH INDICATOR

is a device which makes the engine talk. There are two other kinds of indicators, one costs $50 too much, the other makes the engine tell lies. Better buy the Trill. It is shipped subject to approval.

Ask for Catalog.

Trill Indicator Co., Eagle Street, Corry, Pa.



CRANES

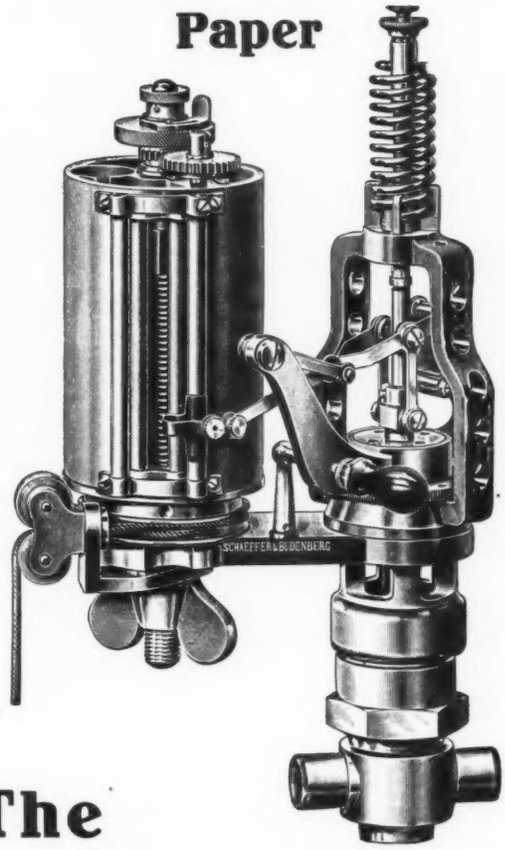
For Power Stations and Shops. Coal Storage Hoisting and Conveying Plants.

Electric and Hand. Catalog Free. Electric Traveling Trolley Hoists and Tracks.

New York:—120 Liberty St.
Philadelphia:—Land Title Bldg.
Chicago:—405 Monadnock Blk.

NORTHERN ENGINEERING WORKS,
5 Chene St., Detroit, Mich., U.S.A.

50 To 100 Indications Without Removal Of The Paper



The Thompson Indicator

makes its record over a period long enough to give reliable information even where constantly changing loads make other indicators practically useless.

The outside spring means a big saving of time and greatly increases the instrument's accuracy; it is always cool in use and easily changed or tested. Write.

The Schaeffer & Budenberg Mfg. Company

Works: Foxboro, Mass.

Salesroom and Offices:

23 Dey St., New York
15 W. Lake St., Chicago

The Robertson-Thompson Indicator

And Victor Reducing Wheel

are invaluable to every ambitious engineer who sees the importance of keeping his engines running at the highest-efficiency, and pushing himself ahead.

It is correct in design, principle and construction. Its records are perfect and always reliable.

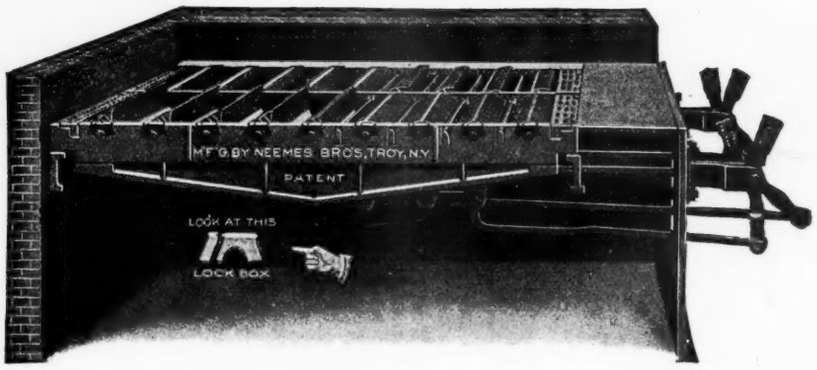
There is no Planimeter equal to the Willis in accuracy or price.

Moderate in Price
Sold on Easy Terms

WRITE FOR DETAILS

Jas. L. Robertson & Sons
46 Warren St., New York

The Only Clinker Cutting, Shaking and Dumping Grate

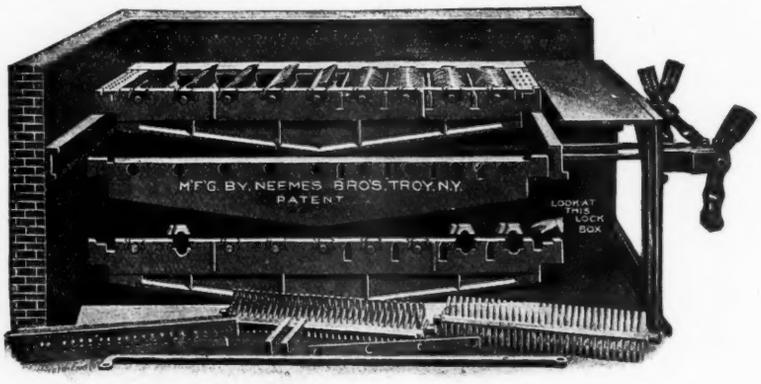


To secure perfect combustion and consequently more heat from a smaller quantity of cheaper fuel, install

NEEMES BROTHERS IMPROVED GRATES

No other grates cut from both sides of the shaker alike. A slight provocation of the lever merely shakes out the ashes but with a full opening a shake or two will dump everything to the ashpit.

Write for full descriptive details.



NEEMES BROTHERS, **41-49 ADAMS STREET, TROY, NEW YORK, U. S. A.**

Manufacturers of Square and Round Grates.

C. W. Van Blarcom, 126 Liberty St., Agent for New York City and vicinity. Babcock & Wilcox, Ltd., Montreal, Canada, Sole Makers for Canada. Burke Engineering Co., 311 Industrial Building, Providence, R. I., Sole Agents for the New England States. Cass Harkins, Hayden Building, Columbus, Ohio.

WASTED STEAM IS WASTED MONEY

If you use the St. John Indicating and Recording Steam Meter you will know your exact steam consumption at any moment and be able to trace any waste and check it. Big economy is possible where the "St. John" is used.

Write For Full Details Today

G. C. ST. JOHN
140 Cedar Street
NEW YORK

JEFFREY TELESCOPIC ASHES ELEVATOR.

Jeffrey

Coal and Ashes Handling Systems for Power Plants.

THE JEFFREY MFG. CO., COLUMBUS, OHIO.

New York Chicago Boston St. Louis Denver Pittsburgh Montreal Knoxville

JUST LIKE FINDING MONEY

When, after smoking up tons of coal, year after year, you install

THE WILKINSON AUTOMATIC STOKER AND SMOKE PREVENTER

and find that 15% less coal does actually more work with lower stoking cost and no waste of fuel.

THE WILKINSON MANUFACTURING CO.
Bridgeport, Montgomery Co., Pa.

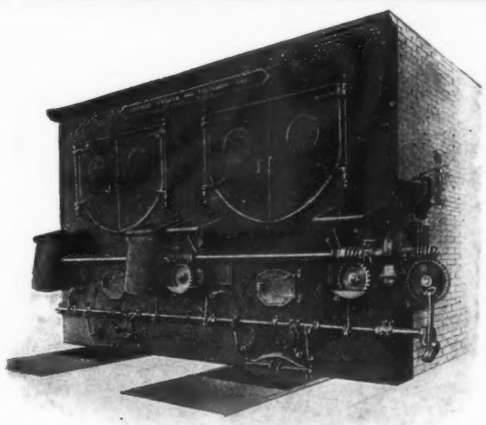
Green Traveling Link Grates
Are Smokeless and Labor Saving.

They operate automatically during all the progressive stages of feeding the coal into the furnace, lighting and coking it. With their use everything combustible is consumed and all refuse is discharged into the ash pit.
Get some particulars now—it will pay you to.

Over 700,000 Horse Power in use.

MANUFACTURED BY

GREEN ENGINEERING COMPANY,
Commercial National Bank Building, Chicago, Ill.
GENERAL FOUNDRY WORK A SPECIALTY.



"The most economical method for Burning Fuel in Power Plants."

Detroit Automatic Stoker

It burns all kinds of coal economically, reducing the fuel bill 10 to 25%.
It adds to the steaming capacity without injury to the boiler shell or tubes.
It feeds and burns the coal and cleans the fires with closed doors.
It insures uniform furnace temperature by continuous, positive feed of fuel.
It does all this with a smokeless stack.

SEND FOR CATALOG.

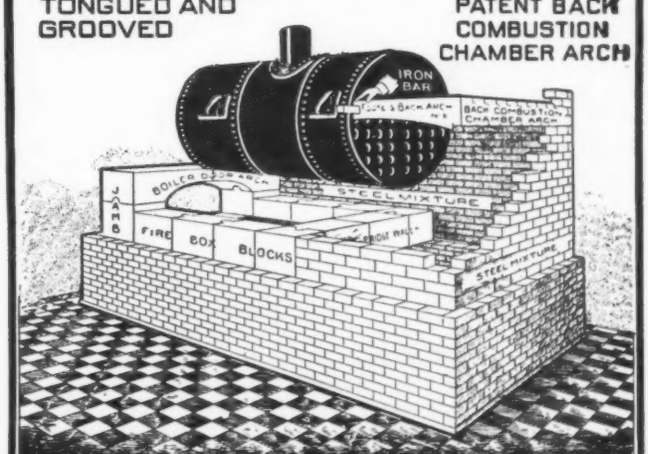
DETROIT STOKER & FOUNDRY CO.
DETROIT, MICH.

"STEEL MIXTURE"

BOILER DOOR ARCHES AND FIRE BOX BLOCKS

TONGUED AND GROOVED

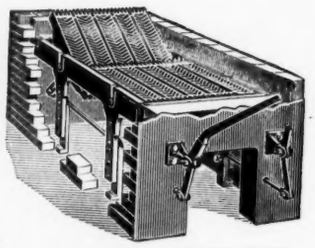
PATENT BACK COMBUSTION CHAMBER ARCH



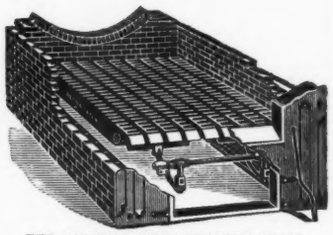
MANUFACTURED BY

McLEOD & HENRY CO.
TROY, N.Y., U.S.A.
BRANCH OFFICE, 1402 BROADWAY, NEW YORK CITY.

Consider the Grate Question



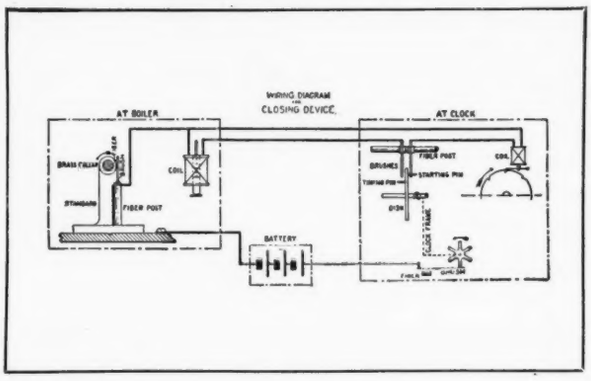
SALAMANDER DUMPING GRATE.



THE ORIGINAL ÆTNA SHAKING GRATE. 60 per cent. Air Space.

If you can burn even the very cheapest coal without loss of efficiency; keep a clean, wasteless fire without even opening the furnace doors and thus save boiler repair costs; the method is worth your attention, is it not? Then write for our "Book of Grates."

Salamander Grate Bar Company,
Telephone, 4136 Cortlandt.
126 Liberty Street, New York.

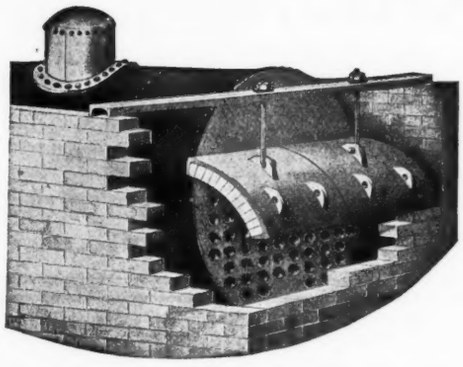


Stop Smoke and You Check Waste

There's *money* going up in smoke as well as unconsumed fuel.
Our Automatic Smoke Preventer turns this loss into profit. The steam and air supplies are automatically regulated, the device being positively operated by a timing arrangement. Simple and absolutely certain in action. Write at once for full information.

Climax Smoke Preventer Co.,
205 Equitable Bldg., BOSTON, MASS.

Stop Crowding That Back Wall!



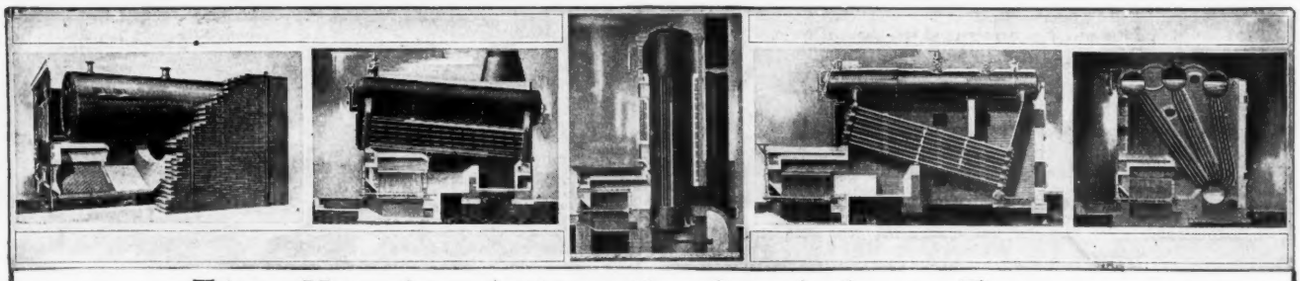
The Monarch Boiler Arch

hangs from above, is easy to set, remove or reset and furnishes easy access to the boiler.

We pay your money back if you don't like it, the Monarch pays it back if you do.

BOOKLET ON REQUEST

Mayville Specialty Mfg. Company
General Founders and Machinists
Mayville, Wis.



Any type of boiler.

The Murphy Automatic Smokeless Furnace

burns slack and other low cost fuels with unexcelled economy and absolute smokelessness. Strictly automatic in feeding and distribution of coal and the removal of the ash. Send for a complete description.

Murphy Iron Works, 5 Walker Street, Detroit, Mich.

Units of any size.

A Scale Preventer *and* Oil Eliminator

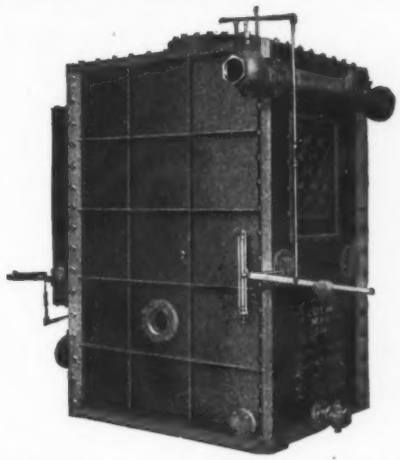
Besides delivering water to the boiler heated with exhaust steam to 210°,

THE OTIS TUBULAR FEED WATER HEATER

separates the oil and the scale-forming impurities before they come in contact with the tubes.
Ask for full particulars.

THE STEWART HEATER CO.
50 Norfolk Ave., BUFFALO, N. Y., U. S. A.

Hot Feed Water Pure Feed Water



The Loew Boiler Feed Water Heater guarantees both. The great problem of the day is the problem of getting along with less fuel. The wise engineer looks to the "LOEW" to help bring this about. By heating the feed water to within 2 to 5 degrees of the exhaust steam, it cuts down fuel bills, besides guaranteeing safety and longer life to the boiler.

CATALOG ?

The Loew Mfg. Co., Cleveland, OHIO.

COES IMPROVED COMBUSTION AND DRAFT SYSTEM

GEO. H. THACHER & CO.,
ALBANY, N. Y.

GRATES OF ALL KINDS. BOILER CASTINGS.

CONTRACTORS.
CENTRAL STATION HEATING.

Write for valuable information.

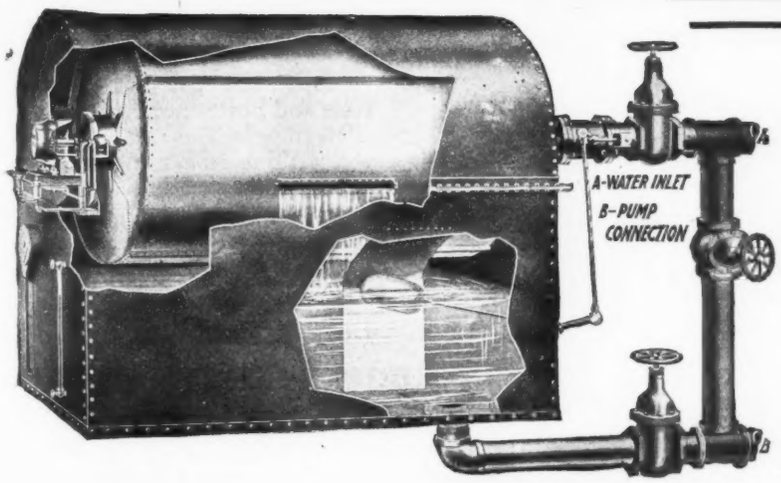
AMERICAN DISTRICT STEAM CO.,
Lockport, N. Y. Toronto, Can. Chicago.

Over 7500 Hammel Oil Burners
In use under Stationary Boilers, Locomotives, Kilns, Etc.
Write for Circular of Hammel Patent Furnace for Water-Tube Boilers
HAMMEL OIL BURNER CO.
609 North Main Street. LOS ANGELES, CAL.

MARTIN GRATES

Martin Anti-Friction Rocking Grates will burn slack coal and get the same steam results as ordinary grates do with best lump coal. Catalog tells why.

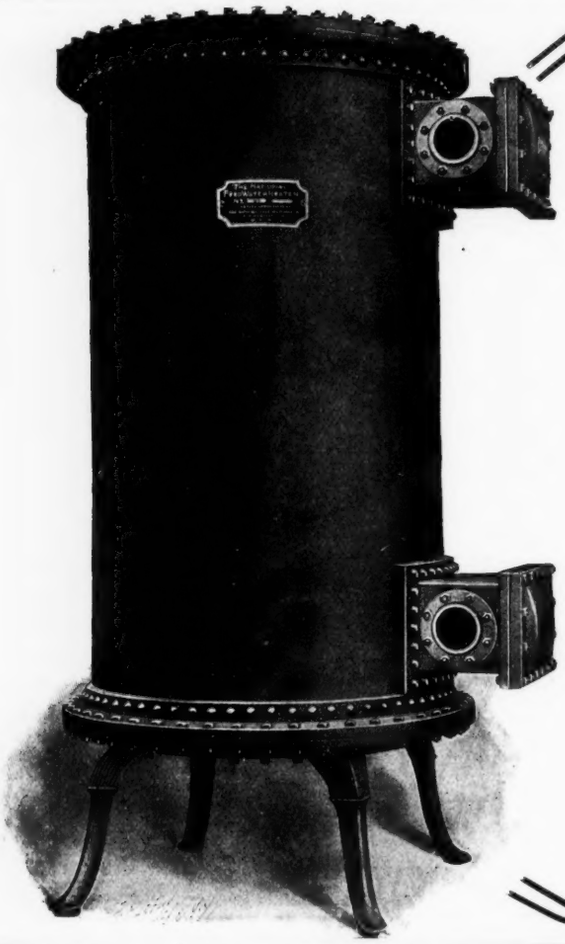
MARTIN GRATE COMPANY, 281 Dearborn Street, CHICAGO.



What Are Your Boilers Doing?

Are you getting the best economy ?
Is your coal best fitted for your purpose ?
Can You Tell Your Evaporation ?
A
DETROIT METER
Will Give You a Continuous Record of Your Boiler Feed Water
Built in all sizes for all requirements of power plants, heating companies and for measuring any liquid.

CENTRAL STATION STEAM COMPANY
Detroit, Mich., U. S. A.
SEND FOR CATALOG.



Seamless Drawn Brass or Copper Coils

which will neither corrode nor collect scale.

The National Feed-Water Heater

is proving uncommonly effective and economic to the extent of 2,700,000 H.P. No contact of water with the iron shell and no possibility of back pressure. *Write.*

The National Pipe Bending Co.

168 River St., New Haven, Conn.

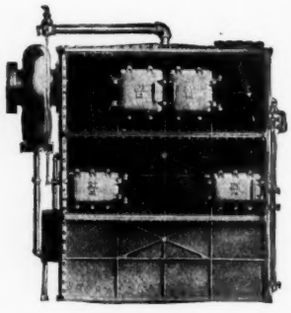
120 Liberty St.
New York

54 High St.
Boston, Mass.

The Marion System

is a step forward. It revolutionizes past methods and is the only known system which *completely purifies* the water without demanding costs of attendance or care.

15% Saving In Fuel and Water



are easily obtained wherever the MARION SYSTEM is installed. The *free* water you consider unfit at present to use as feed water, can be heated, treated, purified and filtered by the Marion System and delivered pure and hot to your boilers, thus saving paying meter rate. Catalog G1.

The Marion INCLINE FILTER and Heater Co.

Marion, Ohio, U. S. A.

No Accident Can Disable

THE

REILLY MULTICOIL HEATER

for more than a few moments.

The engineer by himself can remove and replace any coil—needs only a wrench. All tube connections by standard screwed ground union joints. All accessible through the door in the shell.

Every Coil a Spring—No Leaks.

Coils will not accumulate scale and heater needs no labor of cleaning. This is a fact—if you write us to ask the reason we will show you.

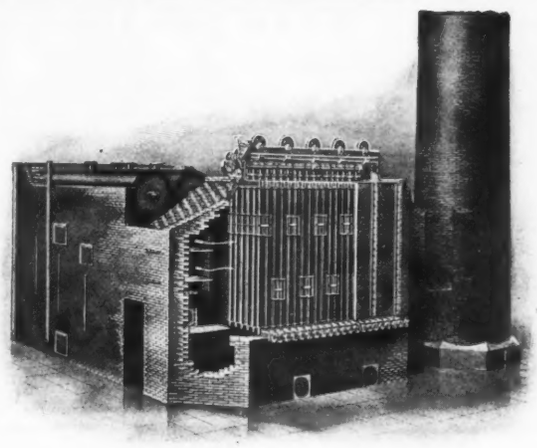
Used by U. S. Govt. Departments because of its efficiency.

Call Our Hand.

THE GRISCOM-SPENCER CO.

90 West Street, NEW YORK.

Boilers --- Engines --- Tanks --- Stacks --- Plant Supplies.



Green Fuel Economizers at the Manhattan Power Station

of the Interborough Rapid Transit Co., New York City, have shown such good results, both in tests and in actual operation, that steam-plant owners and managers are continually asking for details about the installation. We have therefore published a pamphlet on this subject which we will be pleased to send upon application.

There are 64 B. & W. Boilers, rated at 520 B. H. P. each, and 16 Green Fuel Economizers, with 512 tubes each. Running at the average rate, the Economizers supply between 9 and 10 per cent. as much heat as do the boilers themselves, and figuring on this saving alone and deducting the charges for interest, repairs and attendance, they show a return of 30 per cent. per year on their first cost. It has been proven many times, however, that Economizers save a greater quantity of fuel than is indicated by the rise in temperature of the feed water alone. We have explained this in our new treatise, "106 P," which we would be pleased to send upon request. They also protect the boiler from strains from cold water and precipitate scale-forming impurities.

Another point which is even more important in an electric power plant, is that the Economizer stores up a vast quantity of hot water, which greatly increases the capacity of the boilers to carry heavy and sudden overloads. For the proportions in which the Economizer is usually installed this is enough feed water to last about an hour.

As the saving from the Economizer can be accurately known in advance, and as we are prepared to guarantee the depreciation and the up-keep charges, the Green Fuel Economizer offers by far the best and surest investment on the market to-day. You are certain of your dividends (20 to 50 per cent.) and you have the investment under your own control.

Write for the special treatise above mentioned, and also for our Fan Pamphlets.

THE GREEN FUEL ECONOMIZER CO.
MATTEAWAN, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

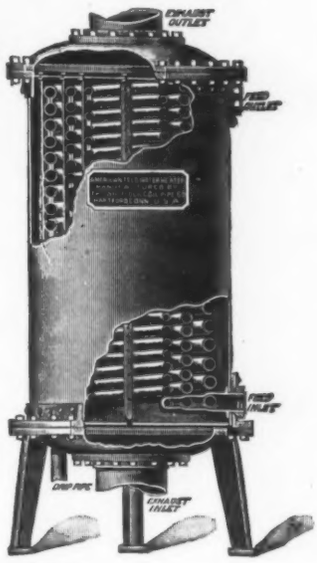
Engineers; Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines. 158

The American Standard Copper Coil Feed-Water Heater

represents the highest type of feed-water heating apparatus and should always be used where the highest temperature and most satisfactory results are desired.

It costs no more than less efficient types.

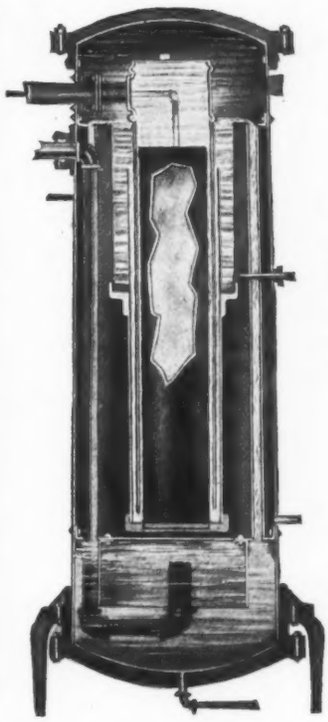
It is the simplest and most widely used type of heater in the market today.



Manufactured by

The Whitlock Coil Pipe Company
Hartford, Conn.
New York Office, Singer Bldg., 85 Liberty St.

The Live Steam Way



of heating and purifying feed-water effects a fuel saving of over 12% above the saving possible with similar devices using exhaust steam.

The Eclipse Feed Water Heater and Purifier

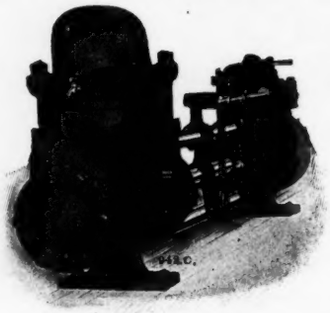
will be sent on trial. If it fails to prove our claims it will not cost you one cent.

BOOKLET ?

The Eclipse Feed Water Heater & Purifier Co.
Oshkosh, Wis.

DEAN BROTHERS STEAM PUMP WORKS

INDIANAPOLIS, IND.

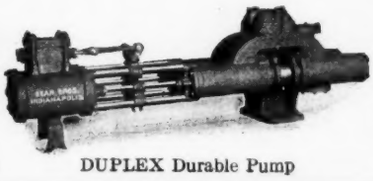


SIMPLE Boiler Feeder

JET AND SURFACE CONDENSERS

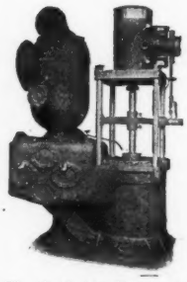
DUPLEX and SIMPLE Steam Pumps

Boiler Feeders
Fire Pumps
Electric Pumps
Vacuum Pumps
Deep Well Power Pumps



DUPLEX Durable Pump

Fly Wheel Pumps
Distillers' Pumps
Plunger Pumps
Ballast Pumps
Atlantic Type Pumps



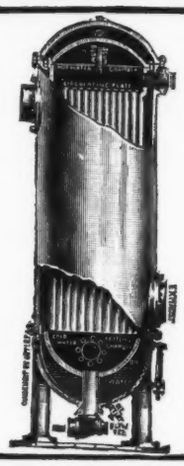
Vertical Air Pump and Jet Condenser

GET A FEED WATER HEATER, BUT—GET A "RIBLET"

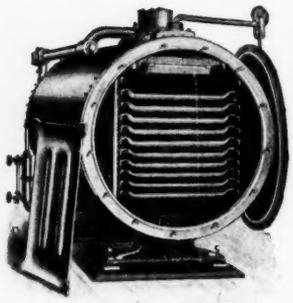
It is certain economy when a steam plant installs a Feed Water Heater, but it is *double economy* when the heater selected is a "Riblet." In the Riblet Feed Water Heater are found advantages in superior construction which guarantees the *highest efficiency*. It can be easily cleaned without removing the piping. Write for other "double economy" features.

ERIE MANUFACTURING & SUPPLY COMPANY,

1203 PEACH STREET, ERIE, PA.

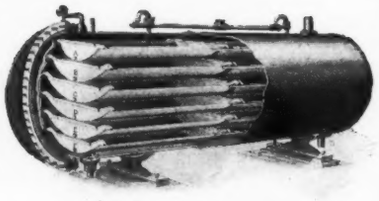


HOPPES



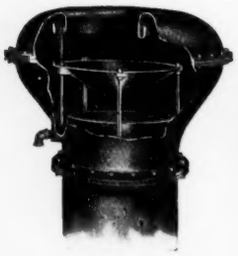
Feed-Water Heater—Class "R"

Exhaust Steam Feed-Water Heaters, Live Steam Feed-Water Purifiers, Steam Separators, Oil Eliminators, and Cast-Iron Exhaust Heads.

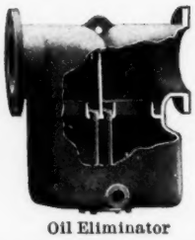


Live Steam Feed-Water Purifier

STEAM SPECIALTIES



Exhaust Head



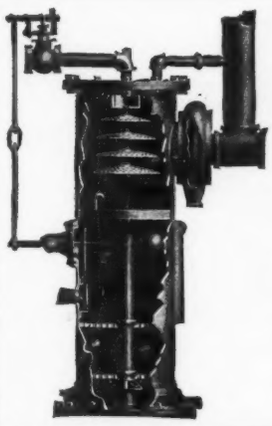
Oil Eliminator

Every machine guaranteed in every respect. Our prices are right.

Send for Our Catalog.

Hoppes Mfg. Co.,
19 Larch Street,
Springfield, - Ohio.

Steam Separators



OUR TWINS

EITHER ONE WILL SAVE 15% of fuel and preserve the boiler.

Write for Prices, Etc.

The Sims Co.,
ERIE, PA.

Branch Office:
136 Liberty St., New York,
Tel., 529 Cortlandt.

SPOT CASH

for your exhaust steam.

Patterson-Berryman Feed Water Heaters

deliver feed water at 210° purified of scale forming impurities. No pay 'till you are satisfied. Write!

Frank L. Patterson & Co.,
28 Cortlandt St., New York, U. S. A.

THE SOCIETY FOR THE PREVENTION OF SCALE

is composed largely of those who use the **Advance Feed Water Purifier.** If you do not belong, you'd better become a life member at once. No Dues! *Circular No.* 30

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COOLING TOWERS

Fan—and Natural Draft

GEORGE J. STOCKER

St. Louis, Mo.

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MYERS POWER PUMPS.

Adapted especially for gas engines, motor and belt powers, in harmony with present requirements. Catalog sent on request.

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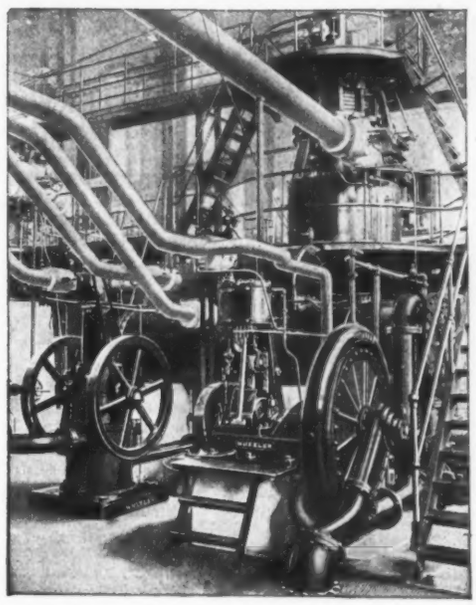
Ashland, Ohio, U. S. A.



A Compact and Simple Condensing Outfit For Steam Turbines

You want a high vacuum for steam turbines, as each inch increase over a 26-inch mercury column results in reducing the steam consumption of the turbine by from 4% to 6%.

We have installed numerous plants like that shown above where a vacuum of 28½ to 29 inches, never less than 28 inches is carried continuously. As you will notice, the above outfit consists of a Wheeler Surface Condenser, a Wheeler engine-driven Centrifugal Circulating Pump, and steam-driven Wheeler-Edwards Air Pump. No dry-vacuum pump, air cooler or hot well pump is required, as the Wheeler-Edwards Pump performs all their functions. It is able to do this, because of the special patented design of the pump cylinder and plunger. There are no foot or bucket valves.

This is all fully described in our treatise "P" on Air Pumps, which we would be pleased to send you.

WHEELER-EDWARDS PUMPS can also be arranged for electric, or belt drive, or in the case of reciprocating engines, direct-driven pumps are supplied if desired.

WHEELER

CONDENSER AND ENGINEERING CO.,
Carteret, N. J.

(Builders of Wheeler Surface, Wet and Barometric Condensers, Wheeler-Volz Combined Surface Condensers and Feed Water Heater, Wheeler Feed Water Heaters, Barnard-Wheeler Cooling Towers, Wheeler-Edwards Air Pumps, Wheeler Centrifugal Pumps, Wheeler Rotative Dry Vacuum Pumps and Wheeler Multiple Effect and Evaporating Machinery).

"BUFFALO"

750 GALLON CENTRIFUGAL UNDERWRITER FIRE PUMP

THE requirements met in the design of the "Buffalo" Centrifugal Fire Pumps are known as the "National Standard Specifications" and have been adopted by the Associated Factory Mutual Fire Insurance Companies, National Board of Underwriters and National Fire Protection Association. Centrifugal pumps are those in which water is given a high velocity by revolving blades termed "impellers." The blades of the impellers are enclosed on the sides by a shrouding extending from the inlet circumference to the periphery, where the water is discharged into "diffusion vanes." Diffusion vanes are provided for receiving the water leaving the impellers at very high velocity and gradually bring it to a lower velocity and prevent losses by shock. The vanes are really a series of nozzles, the water being received at the small ends and passing from the larger ends to the pressure chambers and thence to the next "stage" through a "return chamber."

We furnish hose valves (threaded to template furnished by purchaser) pressure and vacuum gauges, starting valve, steam ejector (or priming valve as required), discharge cone for starting valve, and all necessary oil and grease cups.

We furnish pump, sub-base, coupling, hose valves and gauges as required. Quotations also made on complete equipments including motors.

BUFFALO STEAM PUMP CO.

BUFFALO NEW YORK CHICAGO

No. 16 P

A LITTLE OVER HALF THE STEAM

plus the Baragwanath Syphon Condenser, and you will get results equal in all respects to those you now get without the Baragwanath, but with twice as much steam.

NO AIR PUMP

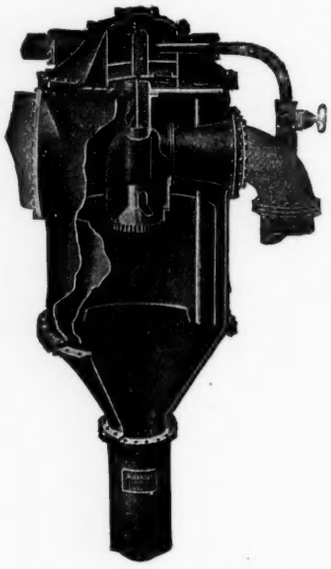
When you come to think of it, the pump is the cause of more trouble than any other feature of the old style condensers.

Write for the catalog.

Wm. Baragwanath & Son,

54 W. Division St., CHICAGO, ILL., U. S. A.

Thos. B. Whitted, Piedmond Bldg., Charlotte, N. C., Southeastern Manager.



Alberger Barometric Condenser

ALBERGER

Complete Condensing Equipments

SURFACE — High Efficiency

CENTRIFUGAL — Internal Air Cooling

BAROMETRIC — High Vacuum

DRY VACUUM PUMPS with Alberger Condensers give highest vacuum

COOLING TOWERS regulated and sub-divided air supply. Perfect water distribution.

WAINWRIGHT HEATERS

Even flow Feed Water Heaters. Distilling Condensers. Hot Water Service Heaters.

High Water Velocity through Straight Corrugated Copper Tubes. Large Capacity. Small Size.

CORRUGATED COPPER EXPANSION JOINTS.

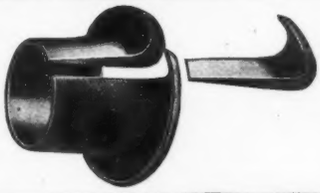
Wainwright Feed Water Heater

ALBERGER CONDENSER COMPANY,

95 LIBERTY ST., NEW YORK, N. Y.

Reeves & Skinner Machinery Company.
617 Chemical Bldg., St. Louis, Mo.

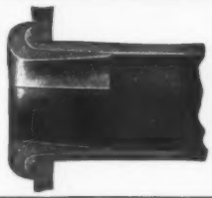
BRANCH OFFICE:
205 La Salle St., Chicago, Ill.



Saves Cost—Avoids Delay

A set of Cruise Tube Protectors will make new tubes of your old ones at a trifling cost. *Write.*

CRUISE & CO., 141-150 Broadway Elizabeth, N. J. Telephone Nos. 745R—526R



Guaranteed to form the best Vacuum by head of water or by supply pump

The Bulkley Injector Condenser

In general use on all classes of engines.

New York Office: 141 Broadway.

Henry W. Bulkley, ENGINEER, Orange, N. J., U. S. A.

STEAM PUMPS

QUALITY AND PRICES ARE RIGHT.

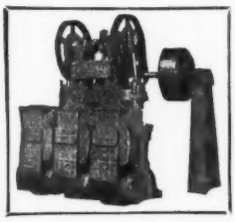
BLAKE PUMP & CONDENSER CO.,

FITCHBURG, MASS.

☞ YOUR LOSS IF YOU DON'T KNOW US.

Deming

Ask for Catalogue "G" and treatise "Feeding Boilers."

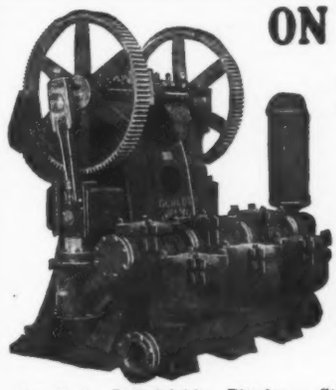


For any service. **Power**

For operation by any power. **Pumps**

The Deming Company

Agencies in Principal Cities Salem, Ohio



ON ACCOUNT

of their extremely low cost of operation and the small amount of attention required

Goulds Efficient Power Pumps

are growing in favor wherever they are installed. Let us send you Catalog of Pumps for every service.

The Goulds Mfg. Co.

Seneca Falls, N. Y.

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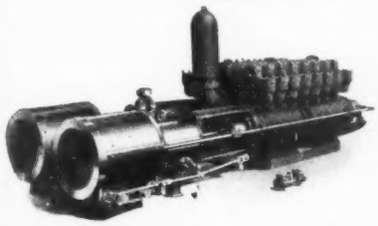
PRESCOTT

50,000 *H.P. Boiler Feed Pump*

We also build a complete line of condensing apparatus.



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Fred. M. Prescott Steam Pump Co.

Milwaukee, Wis.

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WARREN STEAM PUMP CO.,

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PUMPS FOR ALL REQUIREMENTS.

PISTON HYDRAULIC *DEEP WELL PLUNGER* *VERTICAL POWER*

Air Pumps and Jet Condensers.

Combined Air and Circulating and Marine.

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We Make A Centrifugal Pump For Every Use

to which such pumps are adapted. We have been at it for nearly forty years. We make more kinds than any other maker, and we build them in the way that long experience and careful study have shown to be the best way. You know the advantages of Centrifugal Pumps in general; but there are other advantages which we believe are peculiar to our Pumps and we want you to know them.

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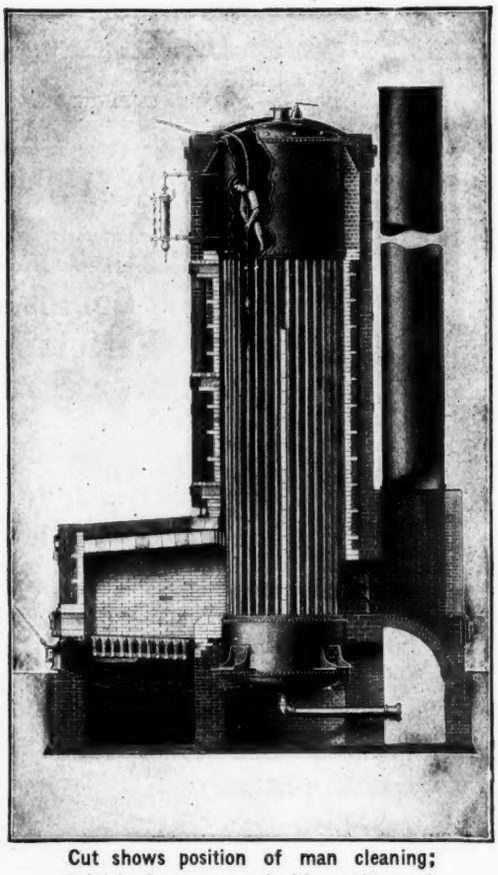
The Wickes Boiler

Vertical Water Tube

Ever cleaned a boiler? Know how hard it is? If you have you will appreciate this boiler at a glance.



Cut shows position of man cleaning; Is it laborious compared with usual forms?

Two 12" x 16" manholes open the Wickes Vertical Water Tube Safety Steam Boiler from top to bottom for inspection and cleaning. Every tube can be looked through; every tube washed or scraped.

Safe.

Low cost of maintenance.

High furnace and heat abstracting efficiency.

Absolutely dry steam.

Ask us for Bulletins—sent free.

The Wickes Boiler Co.

Main Office and Works:

Saginaw, Michigan

Sales Offices:

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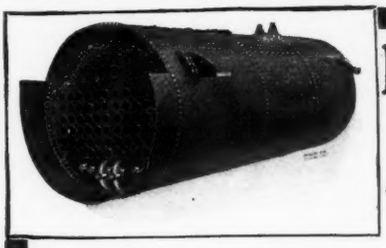
1139 American Trust Bl'd'g, Chicago, Ill.
Penobscot B'ld'g, Detroit, Mich. Empire Bl'd'g, Pittsburg, Pa.
601 Brown-Marx B'ld'g, Birmingham, Ala.



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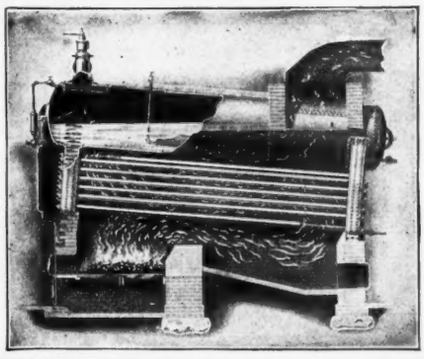
Are Boilers of CHARACTER

They bear the mark of superiority. They are built by mechanics, are strong, solid, substantial, efficient, durable. Have the name KEWANEE in your specifications.

KEWANEE BOILER COMPANY

KEWANEE, ILLINOIS.

FRANKLIN WATER TUBE BOILER

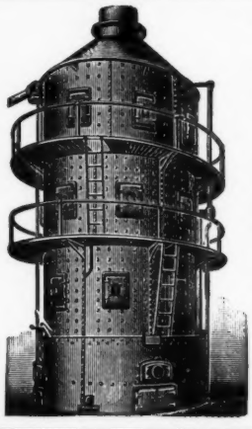


BUILT BY

FRANKLIN BOILER WORKS CO.,

TROY, N.Y.

SALES OFFICE
39 Cortlandt St.,
New York, N. Y.



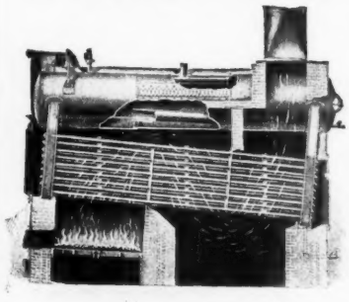
"Climax" is the Boiler to Install.

Why not have a boiler that will do its duty thoroughly? That is, a boiler that will get out of coal and water all the steam possible to get and hold its pressure under unfavorable conditions. That's the "Climax." It's the boiler of the present. Shall we send the Catalog?

The Morrin Climax Boiler Company, BROOKLYN, N. Y.

Main Office: 240 Lorraine Street. Works: Smith, Lorraine, Court & Creamer Streets.
Telephone, 243 Hamilton.

Water Tube Boilers



All Wrought Steel Construction

Ask for New Catalog P. W.

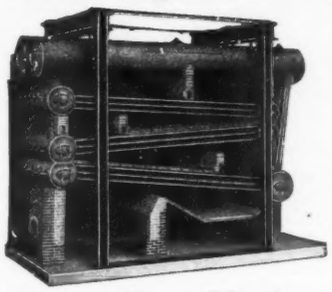
ESTABLISHED 1865.

E. KEELER CO.

Williamsport, Pa.

New York, Philadelphia, Chicago, San Francisco, Wilkesbarre and New Orleans.

No Weight Rests on the Walls



The Vogt Water Tube Boiler is suspended in a steel frame thus eliminating the source of much trouble with brick settings.

CIRCULAR ?

Henry Vogt Machine Company, Inc., Louisville, Ky.

HEINE WATER TUBE BOILERS

AND SUPERHEATERS

All Flange Steel Construction

Send for { Boiler Logic and Superheater Logic

Heine Safety Boiler Co., 421 Olive St., St. Louis Mo.

THE BABCOCK & WILCOX COMPANY

85 LIBERTY STREET, NEW YORK

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STEAM SUPERHEATERS—MECHANICAL STOKERS

Barberton, Ohio — WORKS — Bayonne, N. J.

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San Francisco—99 First Street
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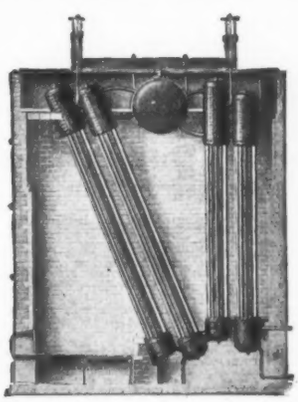
The Bigelow-Hornsby Water Tube Boiler

UNLIMITED SIZE OF UNITS, 2,500 HORSE POWER OR MORE.
COLDEST WATER MEETS THE COLDEST GASES.
DIRECT HEATING SURFACE ABOUT FOUR TIMES AS GREAT AS THE AVERAGE WATER TUBE BOILER.
ALL PARTS, BOTH EXTERNAL AND INTERNAL, READILY ACCESSIBLE.
ALL BOILER TUBES PERFECTLY STRAIGHT.

Large well Illustrated Catalog on request.



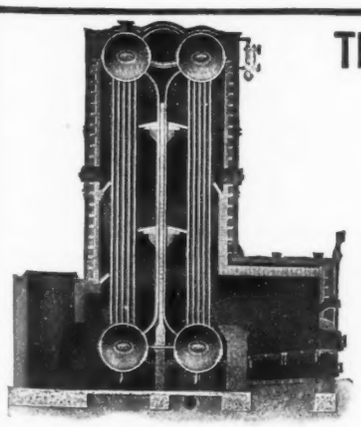
ALL TYPES OF FIRE TUBE BOILERS.

Vulcanizers, dryers, foundry cupolas, tanks, stacks and special work.

THE BIGELOW COMPANY, NEW HAVEN, CONN.

New York Office, 85 Liberty St. **Boston Office, 141 Milk St.**

THE RUST WATER TUBE BOILER



Type B

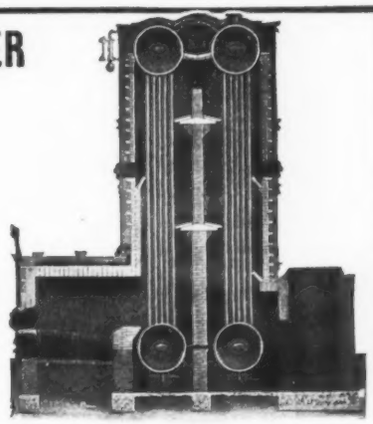
Safe
Simple
Economical
Durable
Accessible

THE RUST BOILER COMPANY,

Pittsburgh, Pa.

THE RUST ENGINEERING CO.
BIRMINGHAM, ALA., and NEW ORLEANS, LA.
SOUTHERN AGENTS.

Write for Report of Tests by William Kent.



Type C

TUBULAR AND WATER TUBE TYPES

TUDOR BOILERS

INCORPORATED 1834

The Tudor Boiler Mfg. Co., - Cincinnati, Ohio

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Watson Steam Pump Governor

For maintaining an even water pressure. Should be used on all steam pumps where a fixed discharge pressure is desired. Designed right and made right, it is automatic and reliable. Send for catalogue.

Watson & McDaniel Co.,
Philadelphia, Pa.

Chas. C. Moore & Co., Engineers.

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CONTRACTORS FOR COMPLETE PLANTS

Power Lighting || Pumping Mining

MACHINERY OF THE HIGHEST GRADE

Now located at our old Site

63 First Street, San Francisco

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Los Angeles, Cal., 321 Trust Bldg. Salt Lake, Utah, Atlas Block.
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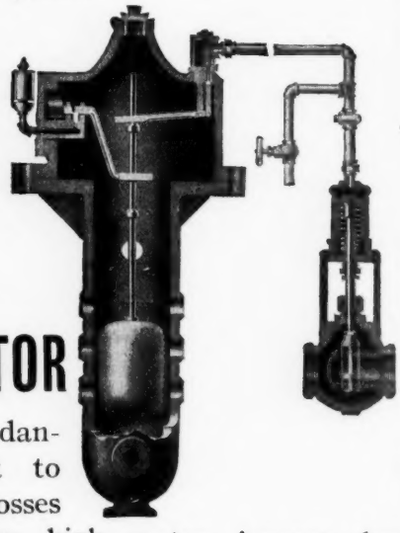
CORRESPONDENCE SOLICITED

There's a direct proportion between the stability of your water level and the profit made by your plant.

THE GOULD FEED WATER REGULATOR



eliminates all dangers incident to low and all losses resulting from high water, insures dry steam.

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THE SAFETY EQUIPMENT MANUFACTURING CO.
Power Plant Specialists
176 E. Lake Street CHICAGO, ILL.

For Half A Century

we have been steadily improving the

Gardner Governor

along the lines of ease, accuracy and economy of adjustment and operation. It was the best 50 years ago and has gained a greater lead each year. Write.

The Gardner Governor and Separator Company,
QUINCY, ILLINOIS.

The Fisher Steam Pump Governor

Simple in construction, absolutely automatic in operation and easily regulated.

It pays in the end to secure THE BEST. That Fisher Governors *are* best, is shown by the fact that *more of them are in use today than all other makes combined.*

Shall we send *you* one on trial?

The Fisher Governor Co., Marshalltown, Ia.

Parker Boiler Company,
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90 West Street.
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Save from 10 to 40% fuel in engines and pumps.

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The Copes Boiler Feed Regulator automatically holds the water level at one point and feeds the water as needed. The Copes Pump Governor controls the feed line pressure. *Write for book "P."*

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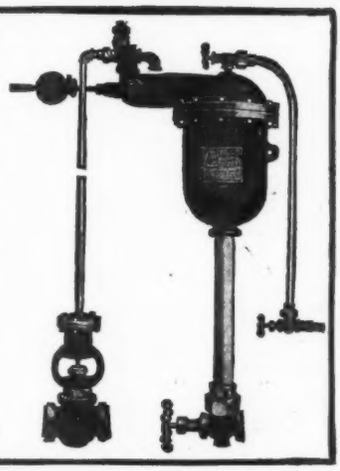
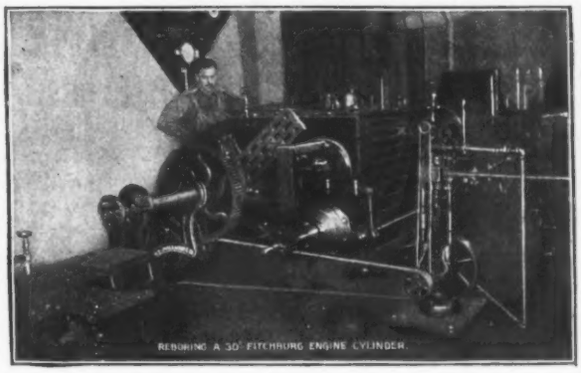
The Vigilant Feed Water Regulator

for Steam Boilers was the first in the field, and has the longest and best record of any of these devices. *Costs less to operate and maintain.* Constructed on a different and better principle than any other. Investigate it and the FULTON PUMP GOVERNOR, and send for latest catalog with list of users. A guarantee from a responsible firm with every machine.



THE CHAPLIN-FULTON MFG. CO.,
PITTSBURG, - PA.
D. W. Patterson, Agent, Harrison Bld., Philadelphia, Pa,



We Do in a Day

the repair work, that, without our services, would cost you weeks of dismantling, shipping, waiting and resetting, to say nothing of added expense and loss of a shut down plant. *Write.*

AMMONIA CYLINDERS INDICATED

H. B. Underwood & Co.
Established 1870
1021 Hamilton St., Philadelphia, Pa.

An Enormous Amount Of Fuel Saved

Perfect regulation of the water level provides the ideal steaming conditions and insures steam storage space for dry steam. The **Murray Automatic Boiler Feed Regulator** is easily the best device ever built for this purpose.

Write for full particulars.

Murray Automatic Boiler Feed Company,
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FOR SALE

One 50 H. P. Tandem Cylinder Gas Engine little used, at a bargain. Also 3 or 4—25, and 30 H. P. Gas Engines at a reduced price. Good as new.

Ajax Iron Works, Corry, Pa.

ALBERGER TANDEM GAS ENGINES
ACCURATE REGULATION FOR ELECTRIC SERVICE-AUTOMATIC CUT-OFF AND RITES FLY-WHEEL GOVERNOR
A.H. ALBERGER COMPANY
45 TO 600 H.P. USING NATURAL GAS
35 TO 500 H.P. USING PRODUCER GAS
695-697 ELLICOTT SQ.
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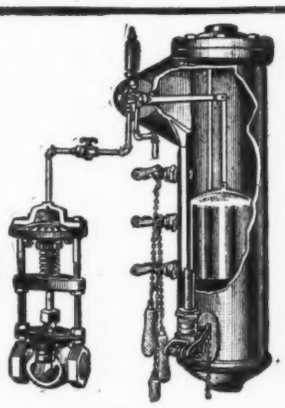
THE
BERRY
Safety
Automatic
Feed Water
REGULATOR



Send for Catalogue
BERRY ENGINEERING COMPANY
Chester, Penn.
Canadian Office, Room 16, No. 17 St. John St., Montreal, Canada.

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.
HARTFORD, CONN

1866 1908

FORTY-FIRST ANNUAL STATEMENT.
JANUARY 1st, 1908.

Capital	$1,000,000.00
Surplus	1,006,868.06
Reserves	2,053,326.74
Assets	4,060,194.80

The HARTFORD was the PIONEER Company in the field of steam boiler insurance and it is the only company which makes a specialty of and does exclusively a steam boiler inspection and insurance business.

The HARTFORD is the only Company whose entire talent and energy are applied to the study of steam, to the scientific construction and installation of boilers and to their periodical inspection by expert mechanics.

The HARTFORD is now doing nearly ⅛ of the inspection and insurance of steam boilers in the New England States, and nearly ⅓ of the entire amount done throughout the United States.

FOOS GAS ENGINES

Producer Gas Plants

Vertical Multiple Cylinder and Horizontal Engines

2 to 500 H. P.

Suitable for all fuels for all power purposes. Speed regulation guaranteed within 2 per cent. from no load to normal. The Foos is the result of TWENTY-ONE YEARS of Gas Engine Experience, and is built in the LARGEST EXCLUSIVE GAS ENGINE PLANT IN AMERICA.

Write to-day for Free 40-page Foos Book K, which tells why the Foos is the WORLD'S GREATEST ENGINE.

THE FOOS GAS ENGINE CO.,
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GENERATORS FOR DIRECT CONNECTION TO ENGINES

SOMETHING NEW 997

During the past two years we have been gradually redesigning our engine type generators. Many improvements have been added and all of the meritorious features of the old type retained.

Our present generator, known as type "L," is the embodiment of the latest practice in generator design.

Send for Bulletin 3355 which fully describes this generator.

NORTHERN ELECTRICAL MFG. CO.,
Standard and Special Electrical Machinery
MADISON, WIS.

OVERCOME YOUR ALIGNMENT TROUBLES!

USE B-M-A FLEXIBLE LINK COUPLING

The ideal method for connecting prime movers to

GENERATORS, BLOWERS, COMPRESSORS, PUMPS, ETC.

Standard sizes up to 500 H.P., but we design them to meet all conditions and will be pleased to learn of yours.

THE BRUCE-MERIAM-ABBOTT CO.,
1688-1692 Columbus Road,
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Full Horse Power At Every Speed.

A wide range of speeds and any one of them obtainable by a simple turn of the hand wheel. The Stow is the only motor absolutely complete in itself.

CATALOG?

Stow Mfg. Company, Binghamton, N. Y.
GENERAL EUROPEAN AGENTS
Selig, Sonnenthal & Co., 85 Queen Victoria Street, London, England.

1 to 75 H. P.

2 and 3 Phase.

15 H.P. 220 V. 1200 R.P.M. 3 Phase Motor.

TRIUMPH

direct current apparatus is known wherever electrical machinery is in use.

WE have a new line of Alternating Current Induction Motors which will be just as well and favorably known.

Your inquiries are solicited. Ask for Bulletin P-321.

TRIUMPH ELECTRIC CO.
Main Office and Works: Cincinnati, O.
Branches in all large Cities.

A TEST
OF A
LOOMIS-PETTIBONE GAS PLANT

operating a 500 B. H. P Gas Engine, showed on a 51-hr. run a consumption of but 1.4 lbs. bituminous coal per K.W.-hr.

Write for particulars to

POWER AND MINING MACHINERY COMPANY,
(Owners and Exclusive Builders.)

New York Office, 115 Broadway.
General Offices and Works, MILWAUKEE, WIS.

OTTO ENGINES

Gold Medal at Jamestown

OTTO OTTO

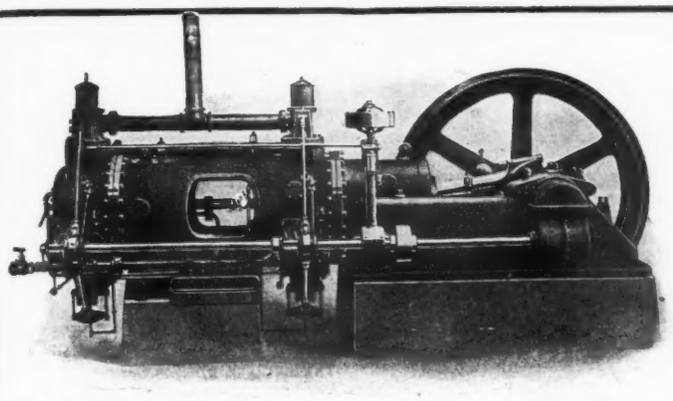
The U. S. GOVERNMENT paid this Company a big compliment when it selected the "OTTO" Engine for use in making fuel tests at the Jamestown Exposition.

The Jury of Awards also proved its fitness for its task when it *awarded* the "*OTTO*" the *GOLD MEDAL.*

The "OTTO" has won *FIRST PRIZE* at every large Exposition held in this Country since the Centennial in '76.

The Otto Gas Engine Works,
Philadelphia, Pa.

STANDARD OF THE WORLD



WARREN GAS ENGINES

Horizontal and Vertical
Types up to 700 H. P.

NOT AN EXPERIMENT

Economy and Reliability Have Been Demonstrated by Actual Service

FULLY GUARANTEED

For All Street Railway, Electric Light and Power Requirements

STRUTHERS-WELLS COMPANY,
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New York Office,
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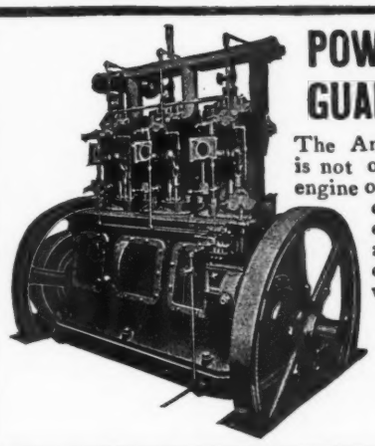


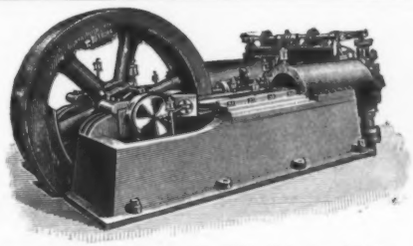
POWER COSTS GUARANTEED

The American Diesel Engine is not only the most efficient engine on earth but it burns the cheapest liquid fuel—crude oil. We can guarantee a cost which no other engine can develop under test.

Write for Catalogue.

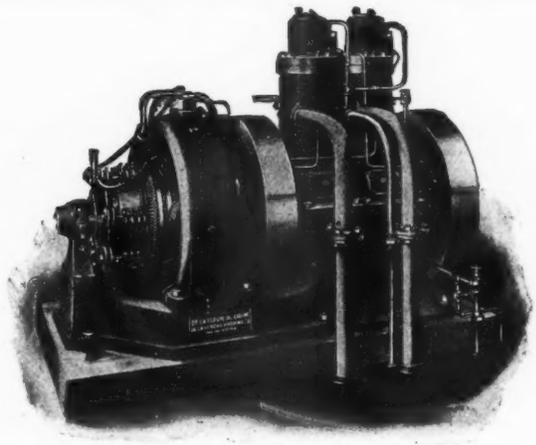
AMERICAN DIESEL ENGINE CO.
11 Broadway, N. Y.

The Miller Gas Engine



is the result of ten years of practical experience in the design of gas engines for heavy duty. It is built in 35, 50, 75, 100, 150 and 250 H.P. sizes. Among its unusual features is our patented system of vacuum governing, which gives a regulation only equaled by the steam engines. The many other good points of this most economical source of power are fully described in the catalog, which is sent on request.

THE MILLER IMPROVED GAS ENGINE CO.,
Springfield, Ohio, U. S. A.



For small and medium sized plants our

OIL ENGINES

are cheaper, simpler, more compact than any other motive power. 8 H. P. hours per gallon of cheap oil.

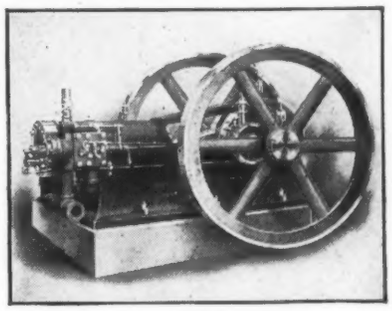
5315 H. P. used by Baldwin Locomotive Works

The "De La Vergne" Vertical two-Cycle 4 to 25 H. P.
"Hornsby-Akroyd" Horizontal Four-Cycle 2 1-2 to 250 H. P.

DE LA VERGNE MACHINE CO.

Foot East 138th Street, NEW YORK.

Du Bois Gas Engines Consume Fuel Only In Proportion To The Load



For general power purposes and especially for electric lighting they afford a greater power on a lighter fuel consumption than any other engine ever built. All parts perfectly interchangeable. Highly heated gases pass from the cylinder through an auxiliary exhaust.

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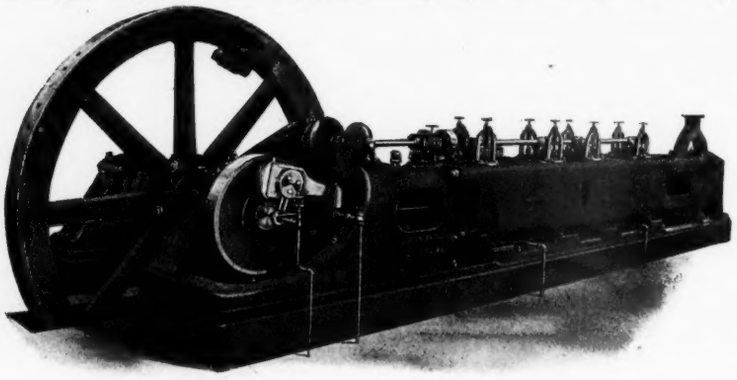
DUBOIS IRON WORKS,
ESTABLISHED 1877.
805 Brady Street, DUBOIS, PA.

A HIGH MECHANICAL EFFICIENCY

Due to simplicity of valve gear, balanced valves, properly constructed metallic packings, a perfected magnetically operated ignition system, along with a consistent distribution of metal gives the



Riverside Heavy Duty Gas Driven Air or Gas Compressor. (Class F.)

RIVERSIDE HEAVY DUTY GAS ENGINE

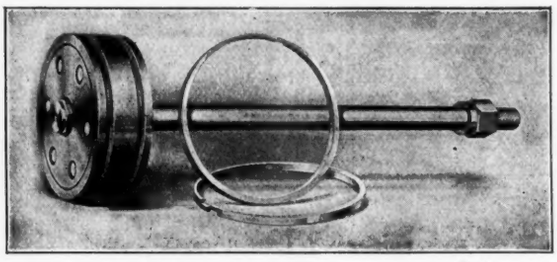
First place. It is wholly unlike any other engine. Built in twelve different types and seventy-two sizes. We also build a complete line of gas-driven air and gas compressors.

RIVERSIDE ENGINE COMPANY, OIL CITY, PA.

New York City, 50 Church St. Pittsburg, Keenan Bldg. Fitchburg, Mass., The Brown-Russell Co. Atlanta, The W. E. Austin Co., Candler Bldg. Indianapolis, Mr. F. Louis Egan, 1130 Congress Ave. Cleveland, Holbeck Co., 924 Rockefeller Bldg.

A HIGH CARBON STEEL ROD

secured into the piston-head by taper fit, forced in by hydraulic pressure, after which a heavy nut is screwed on and the end of the rod is upset.

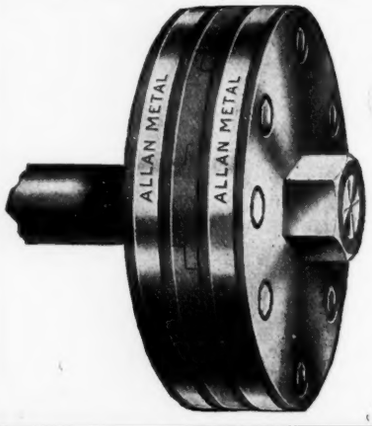


Each part of the Rollins engine is constructed with the same attention to material and the same accuracy of detail shown in the piston construction.

Catalog?

THE ROLLINS ENGINE COMPANY, 29 Mason Street, Nashua, N. H.

Pacific Coast Representatives ARMSTRONG-KRELING MACHINERY CO., San Francisco, Cal.



A Piston Faced With Allan Metal

is bound to give satisfaction under the most unfavorable conditions.

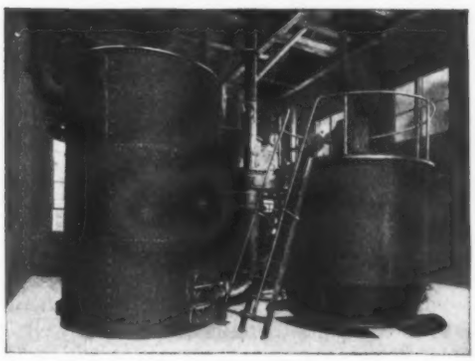
ALLAN METAL will stand the highest pressure and superheat so far practiced. It does not soften under 1500° Fahr.

It is unparalleled as an anti-friction metal.

A. ALLAN & SON, No. 486 Greenwich St., New York.

Cheap Gas of the Proper Quality

for operating gas engines and for other purposes is no longer confined to localities within the "Natural Gas Belt."



Westinghouse Gas Producers

have extended the "gas belt" beyond all former bounds. Cheap power is now available even where coal is expensive. Westinghouse Producers operate automatically and continuously, requiring no skilled attendance. The fact of their being approved by the National Board of Fire Underwriters speaks for itself. Gas Producer Catalogue 7007 contains interesting particulars.

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Atlanta, Candler Building.
Chicago, 171 La Salle Street.
Cincinnati, Traction Building.
St Louis, Chemical Building.
Pittsburg, Westinghouse Building.
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Denver, 512 McPhee Building.
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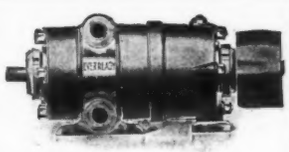
We Manufacture
AN ECONOMICAL AND DURABLE ROTARY ENGINE
Send for Catalogue.



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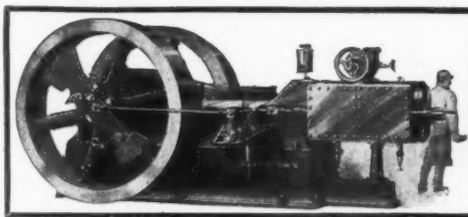
CORLISS ENGINES

Simple, condensing and compound, 50 H. P. to 2000 H. P. Complete steam power outfits for every service. Superior in workmanship and performance.

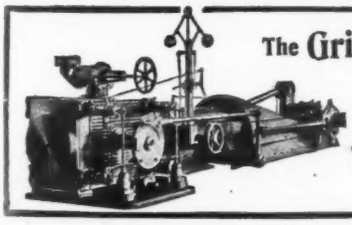
THE BASS FOUNDRY & MACHINE COMPANY,
FORT WAYNE, INDIANA.

A. L. IDE "IDEAL"

MOUND TOOLS. FOR THE ENGINE ROOM.
This cut represents our new set of 20 tools gotten up for use in the engine room. Strictly high-grade tools with all the good points of toolsmithing in their make-up. Conveniently arranged in finished Oak Case and every tool is guaranteed.
No. 20 Set of 20 Tools . . . $4.00.
Book "Engineers' Chums" free. Address Dept, B
MOUND TOOL AND SCRAPER CO.
1606-1608 N. BROADWAY, ST. LOUIS, U. S. A.



Good Engines
for every power purpose. Ask for Catalog.
Watertown Engine Co.,
Watertown, N. Y.



The Griffith & Wedge Co.
Established 1840
Zanesville, Ohio, U. S. A.
Manufacturers of
The Ohio Corliss Engine
and Hoisting Engines

ENGINE AND BOILER BARGAINS

ENGINES

20 x 42 Allis, Corliss	16 x 32 Buckeye, Automatic
18 x 42 Hamilton Corliss	14 x 24 Atlas, Automatic
18 x 36 Wright, Corliss	13½ x 15 Taylor, Automatic
14 x 24 Wright, Corliss	12 x 18 Brownell, Automatic
12 x 24 Wetherill, Corliss	12 x 14 Green, Automatic
10 x 30 Hamilton, Corliss	12 x 12 N. Y. Safety, Automatic

Also large assortment of Automatic and Throttling Engines of other sizes.

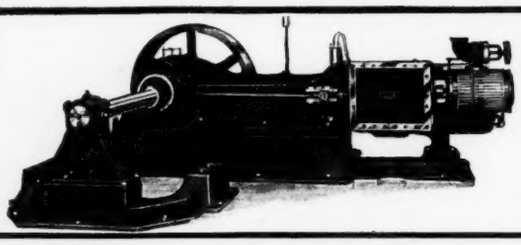
BOILERS

84 x 18, 78 x 16, 72 x 18 High Pressure, 72 x 16, 66 x 16 and smaller sizes of Horizontal Tubular Boilers, also Vertical and Fire Box Boilers from 5 to 60 H. P.

Heaters, Pumps, Tanks, Saw Mills, Iron Working Tools, etc., etc.
Write for bargain list.

We are the sole manufacturers of the celebrated "Leader" Injectors and Jet Pumps.

THE RANDLE MACHINERY CO.
1768 Powers St., CINCINNATI, OHIO.



Skinner Engines

have set a new mark for maintained economy, close regulation and perfection of lubrication.

SKINNER ENGINE CO., - ERIE, PA.

The Lines of

SHEPHERD ENGINES

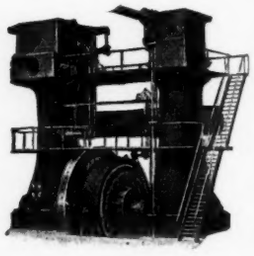
are harmonious and symmetrical too, so that in addition to being good engines they look well. *Catalog?*

SHEPHERD ENGINEERING COMPANY,
Williamsport, Pa.

Reeves Engines have proven their superiority, two standard compounds and one standard single cylinder engines were tested at Cornell University. These tests speak for themselves. Let us tell you more about it.

REEVES ENGINE & MACHINE CO.
Main Office and Works, Trenton, N. J.

HEAVY DUTY
CORLISS
AND
Piston Valve Engines



Mesta Machine Company
Pittsburgh

YOURS On a Minute's Notice

WE HAVE FOR IMMEDIATE DELIVERY:

One 18-inch by 42-inch girder frame engine, left hand, 90 revolutions, rated at 250 h. p; wheel 14-ft. diameter by 48-inch face.

One 19-inch by 42-inch girder frame engine, right hand, 100 revolutions, rated at 280 h.p; wheel 14-ft. diameter by 33-inch face.

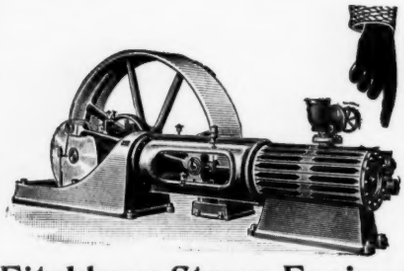
The above are new engines.

One 14-ft. diameter by 28-inch face pulley, turned for belt. Hub bored 11 inches diameter. Wheel weighs 15,000 pounds.

Get busy and communicate with us.

C. H. Brown Engine Co.,
FITCHBURG, Incorporated **MASS.**

REPEAT ORDERS PROVE



that concerns who have used Fitchburg Engines in the past seek none better when further installations are thought of for the future. Half of our business is made up of "repeat orders." And thousands of plants use Fitchburg Engines. There are *reasons*. Allow us to enumerate them.

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Speeds To Suit Standard Generators

Chuse Engines are unrivalled for dynamo driving. They are self-oiling, every bearing being flooded with oil from a reservoir, yet not a drop wasted.

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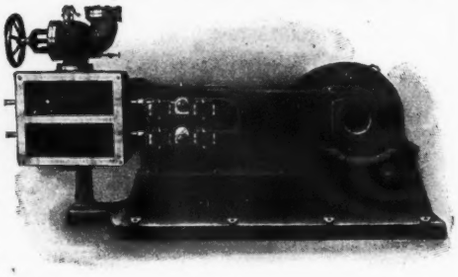

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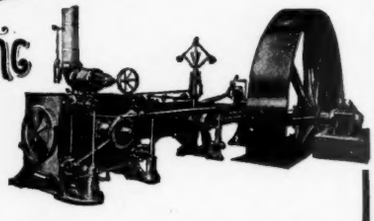
THE IMPROVED FISHKILL CORLISS ENGINE

BUILT BY THE FISHKILL LANDING MACHINE CO., FISHKILL ON THE HUDSON, N.Y.



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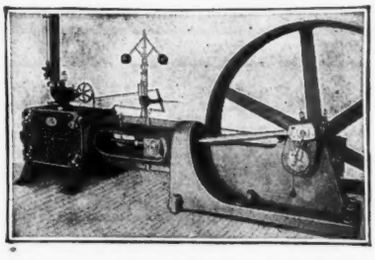

CORLISS ENGINES

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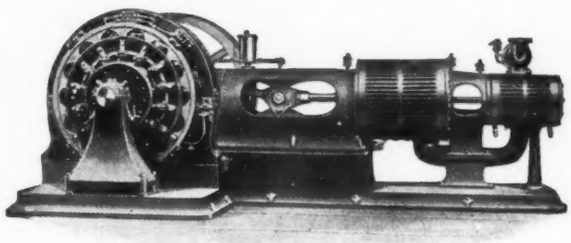
ICE MACHINES

There's No Equally Good Generating Set.



Ridgway Dynamos And Engines

have no close rivals in their line—they are especially adapted each to the other's needs, thus affording such harmonious operation as is only possible where both dynamo and engine are built for the one purpose.

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Ridgway Dynamo & Engine Co.
Works—Ridgway, Pa., U. S. A.

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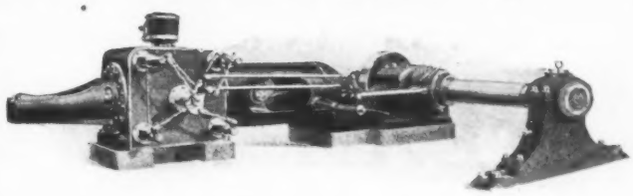

In simple, tandem and cross compound units, and for rotative speeds up to 200 R.P.M. Piston speeds up to 900 feet. THINK what this means to you. It means a saving of over $5000 in the first cost of a 1000 horse power direct connected engine and generator, as against their cost in the standard type of releasing Corliss. It means the maximum of economy and perfect regulation.

The first Corliss engine (size 26 x 36), we ever built has been running 14 years day and night, and is today as good as ever. It's perfect, and must be seen to be appreciated.

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CORLISS ENGINES.

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From 50 to 3000 H. P.
Heavy Duty or Girder Frame.

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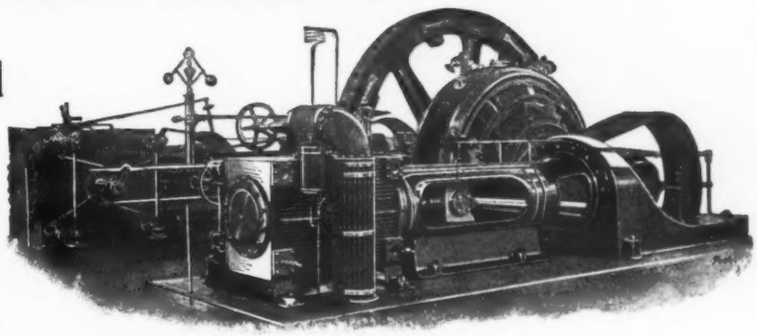

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Horizontal or Vertical, Condensing or Non-Condensing, Simple Cross Compound or Tandem. Designed for Heavy Service of all Kinds, sizes 100 H P. to 7500 H. P. Releasing Gear Engines up to 1000 H. P. at 150 R. P. M.

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Four Valve Non-Releasing Corliss Engines,

Speeds up to 250 R. P. M.

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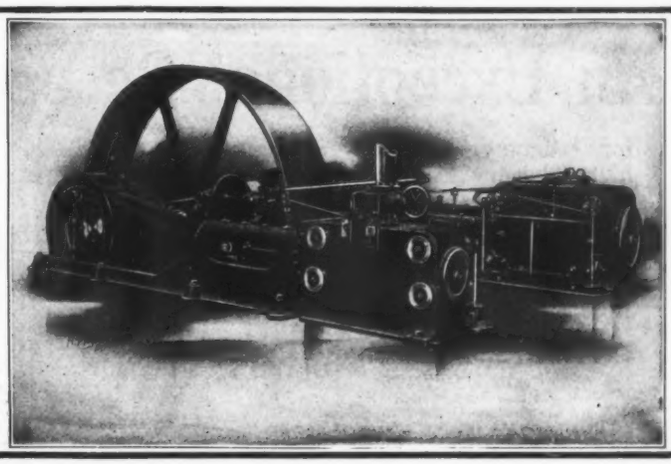

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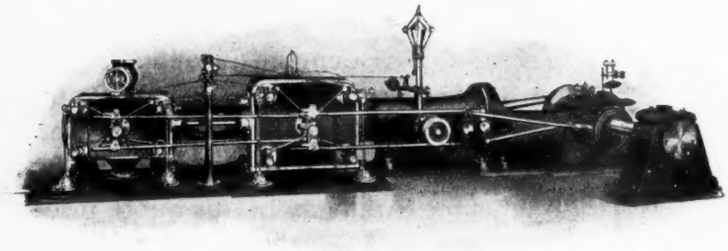

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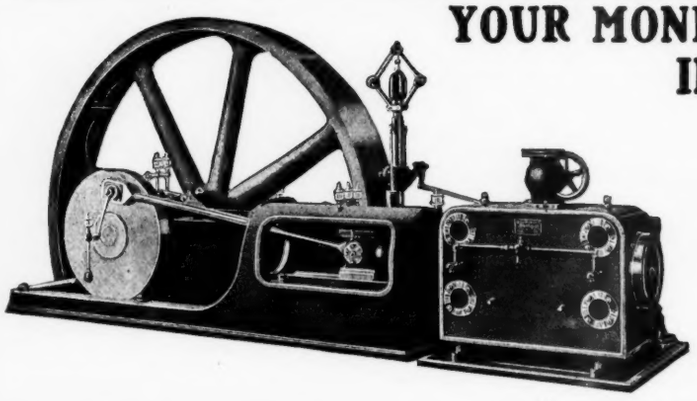

YOUR MONEY'S WORTH AND MORE IN THE HARRIS-CORLISS

Besides being the simplest, best and most reliable in design, workmanship and operation it features the **Brown Patent Release Gear.** This latter feature is found on no other engine. Thus in buying a Harris-Corliss, you get *more* than you would ordinarily. *Write!*

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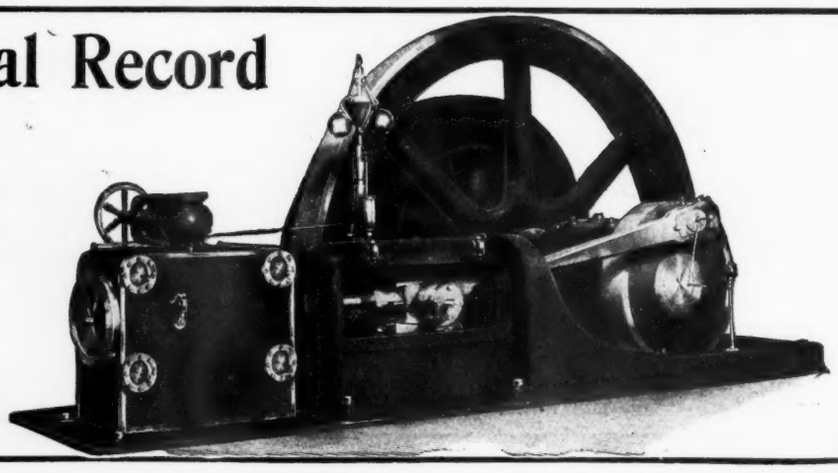
for economy, reliability and high efficiency has been made by the **Cooper Corliss Engine** in electric lighting, railway, rolling mill and general power plant service.



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MURRAY CORLISS ENGINE

Will be sent to any engineer in charge of a power plant who promises to frame and hang it in his engine room. Mention "Power."

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(Incorporated Feb. 1, 1870)

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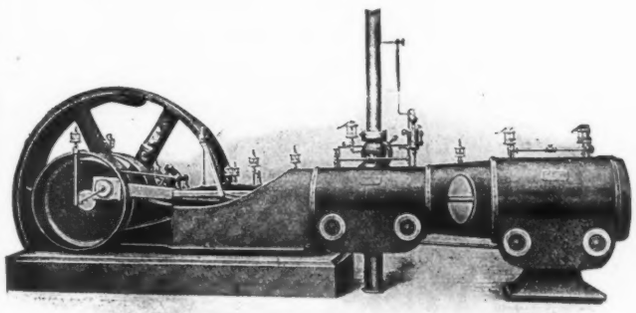

Four Valve Semi-Corliss—Single Valve Enclosed Self-Oiling and Open Types, Simple and Compound, Belted or Direct Connected, Designed Specially for heavy duty, economy and close regulation.

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are known the world over for their satisfactory and economical operation in all kinds of diversified service—built

Simple, Tandem and Cross Compound
in both **Single and 4-Valve Types**

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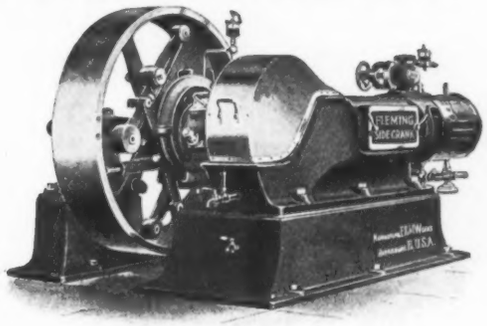

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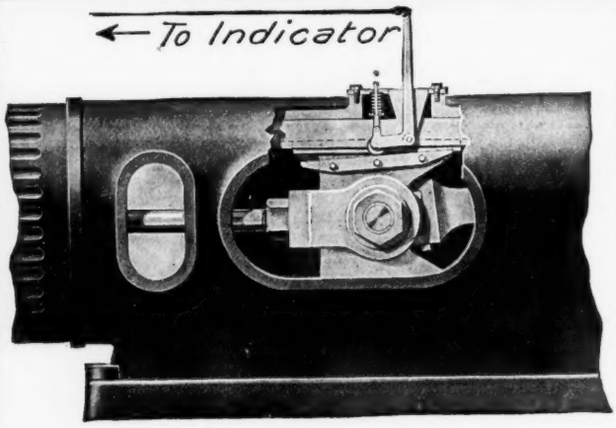
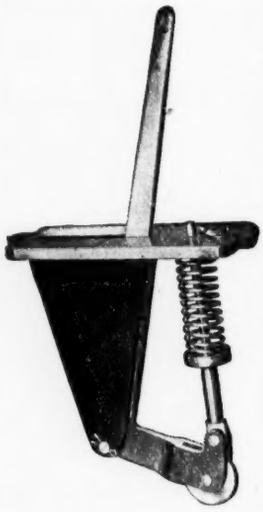


A REDUCING MOTION
IS A PART OF EVERY
American-Ball Engine

Most engines are difficult to indicate, and few engine builders furnish reducing motions with their engines. This is not surprising, for indicator cards show up defects in design.

An indicator reveals any mistakes in valve motions, valves and valve ports and will detect with considerable accuracy undue wear in the steam chest or cylinder.



AMERICAN-BALL engines have no fear of the indicator. We urge frequent use of the indicator, and to assist in its use we build into the engine frame the above reducing motion, which is always ready for taking a card. You can indicate any American-Ball Angle Compound in ten minutes, and it won't take long to discover that it offers a greater H. P. capacity than any other engine that will go into the same floor space.

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How About Adjustments?

How many adjustments does the average steam engineer have to watch and regulate?

How many lubricators, drip cups and bearing gauges require his daily or hourly attention?

How much time is spent in keeping bearings adjusted for wear? How often is it necessary to shut down to "doctor" a bearing adjustment?

How long would the average generating set run without attention to some adjustment?

How many engineers realize the entire freedom from troublesome adjustments with the horizontal Curtis Steam Turbine Generating Set?

Do You?

Figure it out from these facts:

In the turbine there are either two or four self-aligning main bearings supplied with oil by means of chains, or in some cases, a small self-contained pump and outside of the main bearings there are a few small bearings in connection with the governing mechanism, and in some cases with the oil pump.

All governor adjustments are correct when the machine leaves the factory and need no attention after machine is first started.

There are many points of simplicity and reliability about these sets that every engineer should know.

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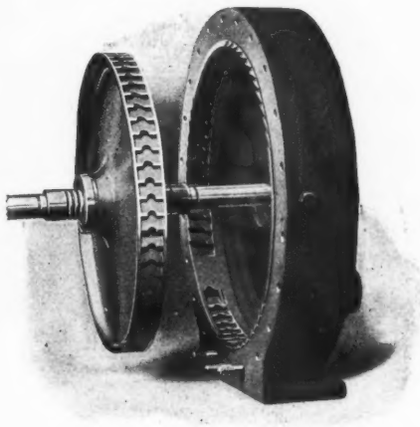
The Sturtevant Steam Turbine



Is more simple, more durable, and of less weight than any other turbine built in this country.

Indestructible Buckets and Low Speed are Special Features

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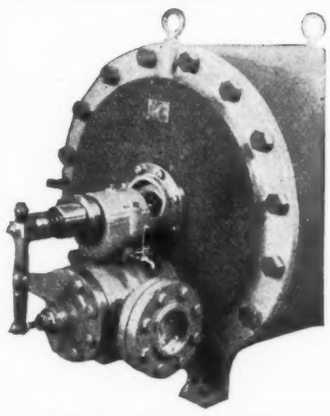

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TURBINE PUMPS for water works, condensers and boilers. Require less steam, attention, oil and space than direct acting piston pumps. Wide range of capacity and head.

TURBINE GENERATORS. Direct current 2 kw. to 150 kw., standard voltages. Alternating current 25 to 250 k. v. a., 60 cycle, standard voltages to 2200. Regulation close.

TURBINE BLOWERS for gas works, foundries and forge shops. No belts or reducing gears. Started or stopped quickly. Capacity up to 100,000 cu. ft. per minute. Pressure up to 16 ozs.

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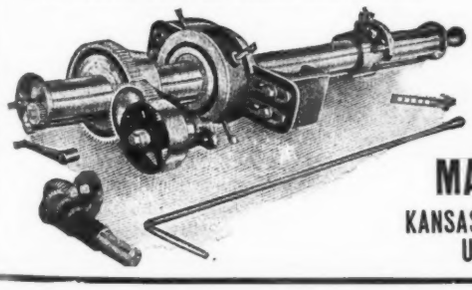
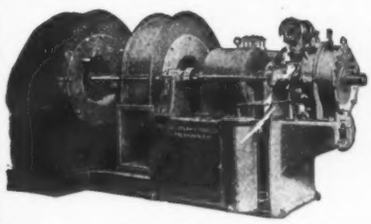
of your cylinder reboring troubles and save expense, delay and worry. With this Portable Boring Bar you can rebore between sunset and sunrise.



Write.

HUGH MATHEWS
KANSAS CITY, MO., U. S. A.

DE LAVAL



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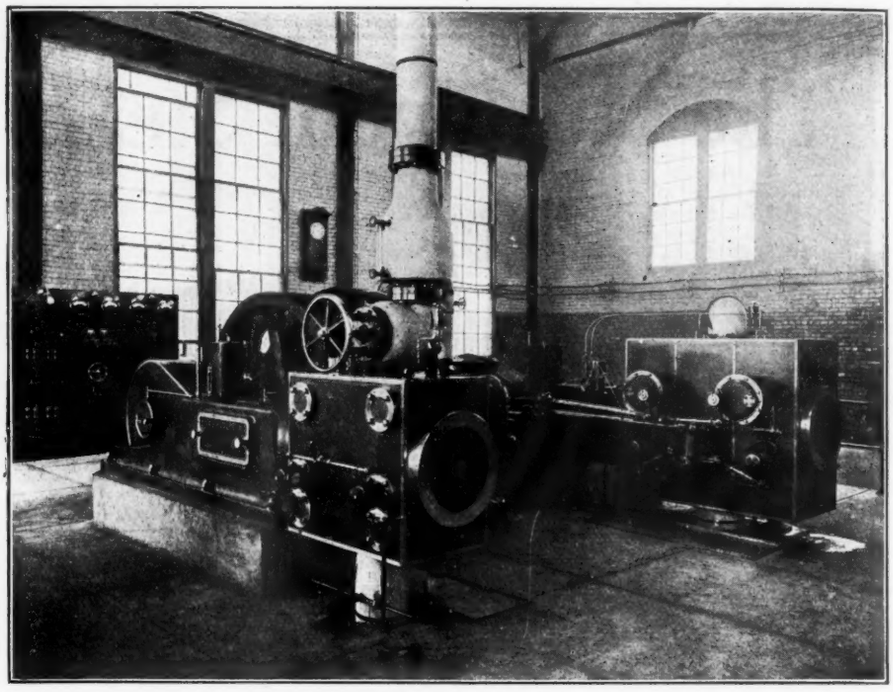

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Direct Connected to Generator, in Dean Electric Co. Plant, Elyria, Ohio.

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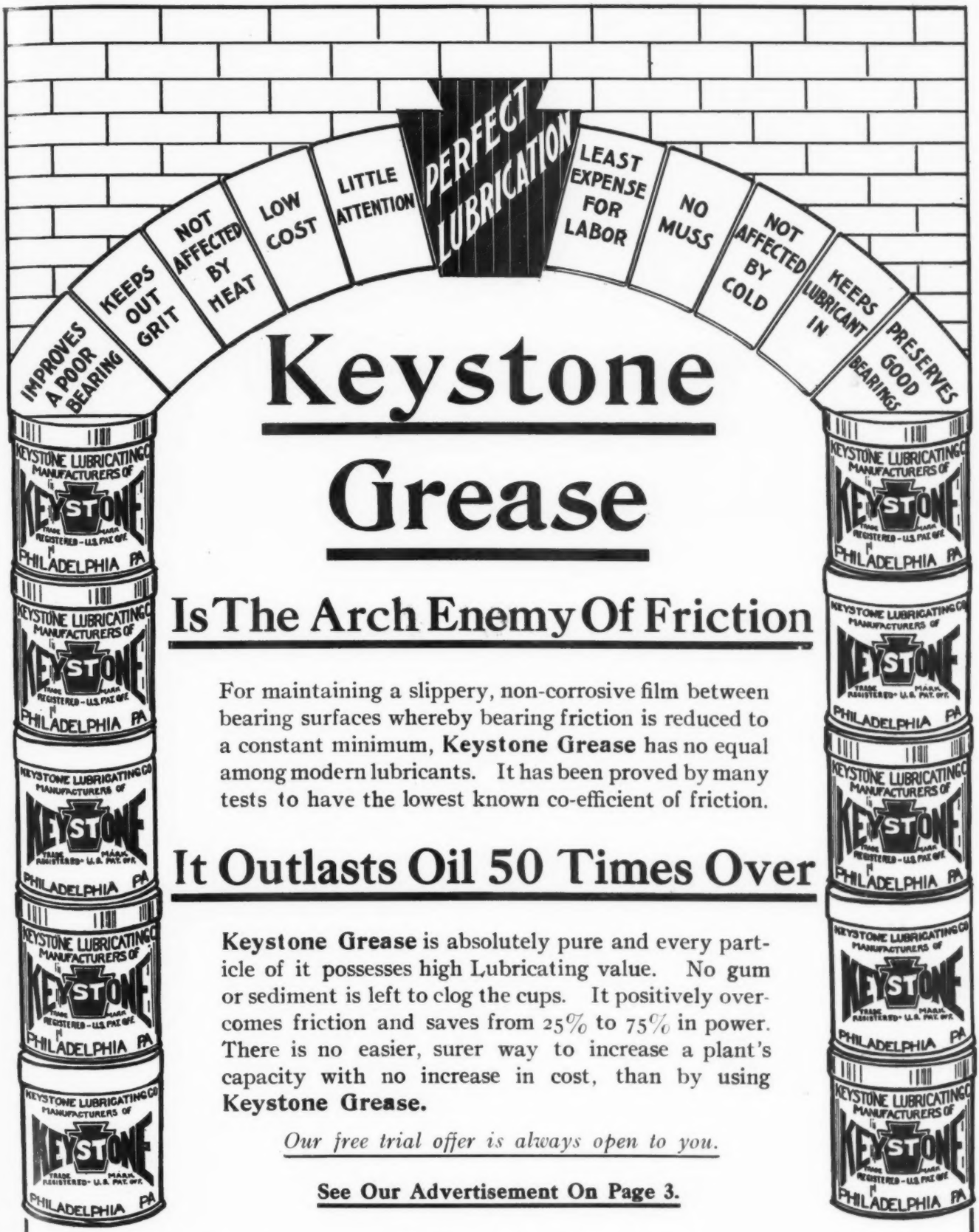

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Keystone Grease is absolutely pure and every particle of it possesses high Lubricating value. No gum or sediment is left to clog the cups. It positively overcomes friction and saves from 25% to 75% in power. There is no easier, surer way to increase a plant's capacity with no increase in cost, than by using **Keystone Grease.**

Our free trial offer is always open to you.

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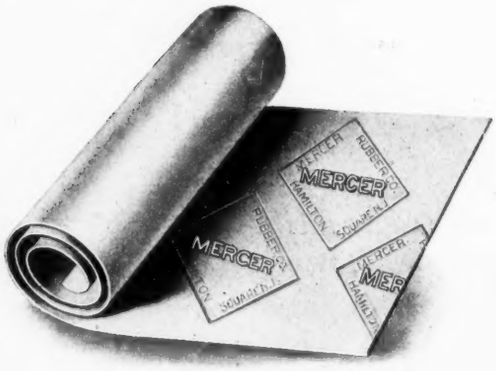

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A Semi-Vulcanized Composition of Graphite and Rubber for Steam Joints, Hot Air Joints, Hot Water Joints, Cold Water Joints—It is applied in a semi-vulcanized condition and readily adapts itself to any uneveness of surface. When steam is applied it vulcanizes the packing, makes it metal-like and forms an absolutely solid union—oil does not affect it as it does rubber packing.

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